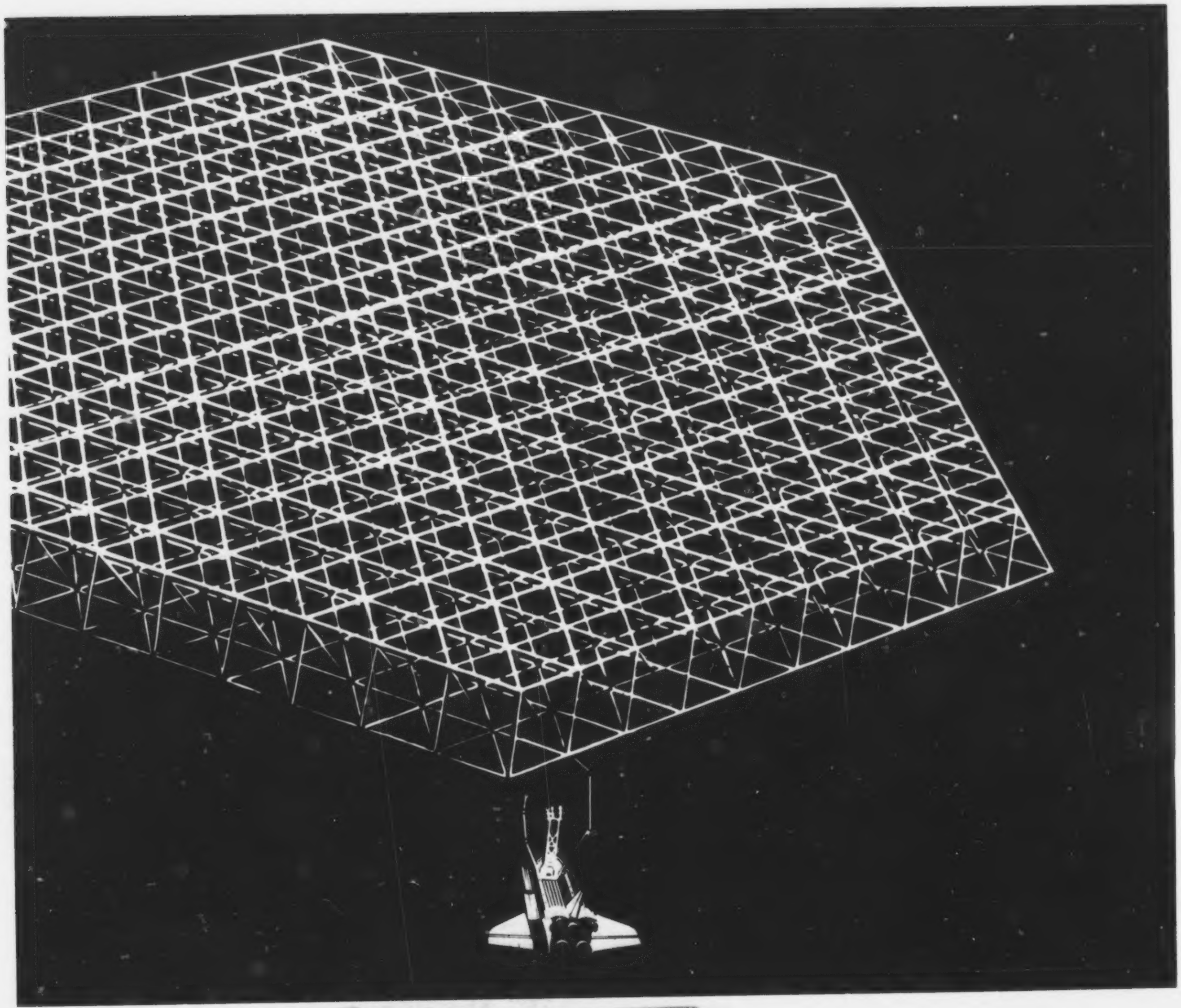
7046(20)

NASA

Technology for Large Space Systems

A Bibliography
with Indexes

NASA SP-7046(20)
June 1989



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NOTE TO AUTHORS OF PROSPECTIVE ENTRIES:

The compilation of this bibliography results from a complete search of the *STAR* and *IAA* files. Many times a report or article is not identified because either the title, abstract, or key words did not contain appropriate words for the search. A number of words are used, but to best insure that your work is included in the bibliography, use the words *Large Space Structures* somewhere in your title or abstract, or include them as a key word.

This supplement is available from the National Technical Information Service (NTIS), Springfield , Virginia 22161 at the price code A09.

NASA SP-7046(20)

TECHNOLOGY FOR LARGE SPACE SYSTEMS

A BIBLIOGRAPHY WITH INDEXES

Supplement 20

Compiled by
Technical Library Branch
and
Edited by
Space Systems Division
NASA Langley Research Center
Hampton, Virginia

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system between July 1 and December 31, 1988 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Division
Washington, DC 1989

INTRODUCTION

This bibliography is designed to be helpful to the researcher and manager engaged in the developing technology within the discipline areas of the Large Space Systems Technology (LSST). Also, the designers of large space systems for approved missions (in the future) will utilize the technology described in the documents referenced herein.

This literature survey lists 694 reports, articles and other documents announced between July 1, 1988 and December 31, 1988 in *Scientific and Technical Aerospace Reports (STAR)*, and *International Aerospace Abstracts (IAA)*.

The coverage includes documents that define specific missions that will require large space structures to achieve their objectives. The methods of integrating advanced technology into system configurations and ascertaining the resulting capabilities is also addressed.

A wide range of structural concepts are identified. These include erectable structures which are earth fabricated and space assembled, deployable antennas which are fabricated, assembled, and packaged on Earth with automatic deployment in space, and space fabricated structures which use pre-processed materials to build the structure in orbit.

The supportive technology that is necessary for full utilization of these concepts is also included. These technologies are identified as analysis and design techniques, structural and thermal analysis, structural dynamics and control, electronics, advanced materials, assembly concepts, and propulsion.

A separate companion document "Space Station Systems Bibliography" (NASA SP-7056) incorporates space station technology not applicable to large space systems. Space station systems technology that is also applicable to large space systems may be documented in both bibliographies.

Robert L. Wright, *Space Systems Division*
John Ferrainolo, *Technical Library Branch*

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

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ACCESSION NUMBER	**N88-20235*#** National Aeronautics and Space Administration.	CORPORATE SOURCE
	Ames Research Center, Moffett Field, Calif.	
TITLE	**WORKSHOP ON TECHNOLOGY DEVELOPMENT ISSUES FOR**	
	THE LARGE DEPLOYABLE REFLECTOR (LDR)	
AUTHOR	KENJI NISHIOKA, ed. Feb. 1986 118 p Workshop held in	
	Asilomar, Calif., 17-22 Mar. 1985	PUBLICATION DATE
REPORT NUMBERS	(NASA-CP-2407; A-85394; NAS 1.55:2407) Avail: NTIS HC	
PRICE CODE	A06/MF A01 CSCL 03B	COSATI CODE

The results of the 2nd Large Deployable Reflector (LDR) Technology Review Workshop held at Asilomar, California, March 17 to 22, 1985, are summarized. The workshop was convened to update LDR Technology status and to revise as necessary the results for the first LDR Workshop held in June 1982. There were some 100 participants representing government agencies, industry, and universities. This Workshop's goal was to assess, identify, and set priorities for the LDR technology issues based on requirements identified in the first workshop. Four high-priority technology areas were identified: (1) mirror materials and construction; (2) sensing and controls; (3) system-simulation and modeling capability; and (4) submillimeter instruments. The results of the workshop were used to provide a list of technolgy issues for the development of a technology initiatives plan for the LDR by NASA's Office of Aeronautics and Space Technology. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER	**A88-13932*** California Univ., Los Angeles.	
TITLE	**DISTURBANCE AND VIBRATION ISOLATION IN SPACE**	
	STATIONS BY MEANS OF MECHANICAL DECOUPLING	AUTHOR'S AFFILIATION
AUTHOR	P. K. C. WANG (California, University, Los Angeles) International	
JOURNAL TITLE	Journal of Control (ISSN 0020-7179), vol. 46, Sept. 1987, p.	
	1061-1082. NASA-supported research. refs	JOURNAL DATE
CONTRACT NUMBERS	(Contract NSF ECS-85-09145)	

A decoupling approach to disturbance and vibration isolation in large space stations composed of modules interconnected by flexible members is proposed. A simplified mathematical model for the motion of the space station core and a laboratory module with both torsional vibration and translational motion decouplers is used in this study. The dynamic behavior of the model in the presence of decoupler friction is analyzed. Estimates for the maximum excursions of the laboratory module induced by various types of external disturbance are derived. The paper concludes with a simulation study involving the hard-docking of a space shuttle with a space station. Author

TECHNOLOGY FOR LARGE SPACE SYSTEMS

A Bibliography (Suppl. 20)

JUNE 1989

01

SYSTEMS

Includes mission and program concepts and requirements, focus missions, conceptual studies, technology planning, systems analysis and integration, and flight experiments.

A88-33434*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

TECHNOLOGY ADVANCEMENTS FOR THE U.S. MANNED SPACE STATION - AN OVERVIEW

WILLIAM E. SIMON (NASA, Johnson Space Center, Houston, TX) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 75-87. refs

The structure and methodology of the Johnson Space Center (JSC) advanced development program is described. An overview of the program is given, and the technology transfer process to other disciplines is described. The test bed and flight experiment programs are described, as is the technology assessment which was performed at the end of the Phase B program. The technology program within each discipline is summarized, and the coordination and integration of the JSC program with the activities of other NASA centers and with work package contractors are discussed. C.D.

A88-34537* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

ASTROPHYSICS SPACE OBSERVATORIES - THE NEXT 25 YEARS

S. H. MORGAN, M. E. NEIN, J. HOWELL (NASA, Marshall Space Flight Center, Huntsville, AL), and D. KOCH (Smithsonian Astrophysical Observatory, Cambridge, MA) IN: Reflective optics; Proceedings of the Meeting, Los Angeles, CA, Jan. 15, 16, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 2-23. refs

The design characteristics and performance capabilities of orbiting astrophysical observatory optics are projected from the state-of-the-art to the next 25 years. Attention is given to the possible features of large optical/UV observatories as well as to an advanced gamma-ray observatory that could employ the Space Shuttle's External Tank as its structural basis. It is noted that telescope performance has reached fundamental technological barriers to further progress which demand radical innovations in optical configurations' design. O.C.

A88-34552

POLAR PLATFORM CONFIGURATION AND SERVICING

P. J. CONCHIE and E. P. L. WINDSOR (British Aerospace, PLC, Space and Communications Div., Bristol, England) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 37-44.

The design concept and operation of the ESA Columbus Polar Platform, a spacecraft intended for ELV (Ariane 5 or Titan 4) launch to an 850-km sun-synchronous orbit and subsequent servicing by the NASA STS, are discussed. The factors influencing the design process are outlined; the system requirements are defined; and the present platform configuration is presented in drawings and described in detail, with reference to power supply (4.0 kW in daylight and 3.0 kW in eclipse), data rates (500 Mb/s via EDRS or 300 Mb/s via NASA TDRSS, plus 300 Mb/s via a direct X-band link), data recording capacity (30 Gb), pointing accuracy (0.03 deg), servicing needs (3 times in 10 yrs), and lifetime (30 yrs). The payload section provides 27 sq m of attachment area for 2500 kg (net) of earth observation, solar terrestrial physics, life science, and communication experiments. T.K.

A88-34563

COLUMBUS UTILIZATION STUDIES - ATTACHED PAYLOADS

A. BIELZA and A. ALDAMIZ (Sener, S. A., Las Arenas, Spain) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 159-162.

The types of payload components which could be attached to the main structure of the International Space Station in its IOC stage are discussed, summarizing the results of ESA utilization studies. The basic payload set is listed and briefly characterized; the buildup sequence for the Space Station is reviewed; a payload mission baseline is established on the basis of NASA constraints on the availability of attachment points and Payload Attach Equipments for ESA payloads; and economic aspects are considered. The need to negotiate more clearly defined regulations on attached payloads is indicated, with an emphasis on the implications for space commercialization. T.K.

A88-34573* National Aeronautics and Space Administration, Washington, DC.

THE INTERNATIONAL SPACE STATION COMPLEX - PROMISE AND PROBLEMS

RICHARD E. HALPERN (NASA, Utilization Office of Space Station, Washington, DC) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 213-219.

The current planning status of the International Space Station is reviewed from a NASA perspective, with a focus on aspects affecting the contributions of the international partners ESA, Japan, and Canada. The modifications implied by the shift from the previous double-keel configuration to the current phased-deployment (Block 1 - Block 2) approach are considered in detail and illustrated with drawings and a table listing the baseline assembly sequence. It is pointed out that the originally proposed non-NASA components can all be accommodated in the new configuration. The need for intermodule commonality of equipment form, fit, and function is discussed, and it is recommended that independent user boards be set up to select and coordinate experiments, and that the user boards of the partners open channels of cooperation and mutual support. T.K.

A88-34574

JAPANESE SPACE STATION PROGRAM

K. HIGUCHI and T. YAMAWAKI (National Space Development Agency of Japan, Space Experiment Group, Tokyo, Japan) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 221-227.

Since May 1985, when Japan first began participating in the Space Station program, the NASDA has been studying the JEM concept and related Space Station system issues in cooperation with NASA, ESA, and Canada. In a parallel activity, the Space Activities Commission Ad Hoc Committee on the Space Station has been discussing Japan's policy for future phases. This paper presents Japan's approach for participating in this program, the concept, the development plan, Japan's candidate sensor for Polar Platform, and the future program for promoting space environment utilization. Author

A88-35052* National Aeronautics and Space Administration, Washington, DC.

SPACE STATION DEVELOPMENT

EDWIN E. SPEAKER (NASA, Washington, DC) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 3-11.
(AAS PAPER 86-255)

NASA has recently completed an in-depth review of the Space Station Program plan and is considering several changes to the baseline configuration and to the launch and assembly sequence. These configurational changes will facilitate development as well as system operation, although a few more launches are required. However, the new sequence will allow more useful payload activities earlier than previously planned, and will still result in a permanently manned capability by 1994. Author

A88-35053* National Aeronautics and Space Administration, Washington, DC.

SPACE STATION EVOLUTION

DAVID C. BLACK (NASA, Washington, DC) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 13-15.
(AAS PAPER 86-262)

The Space Station that will be launched and made operational in the early 1990s should be viewed as a beginning, a facility that will evolve with the passing of time to better meet the needs and requirements of a diverse set of users. Evolution takes several forms, ranging from simple growth through addition of infrastructure elements to upgrading of system capability through inclusion of advanced technologies. Much of the early considerations of Space Station evolution focused on physical growth. However, a series of recent workshops have revealed that the more likely mode of Space Station evolution will not be through growth but rather through a process known as 'branching'. Author

A88-35056

THE COLUMBUS RESOURCE MODULE FOR THE EUROPEAN MAN-TENDED FREE FLYER

KLAUS FAHLENBOCK (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 89-101.
(AAS PAPER 86-465)

In April, 1986, it was decided that the ESA Man-Tended Free Flyer (MTFF) would become a dedicated element of the NASA Space Station, with a permanently coupled Resource Module/Pressurized Module configuration. Attention is presently given to the Resource Module's design-driving requirements, the MTFF/Resource Module reference configuration, first and second MTFF versions, and the Space Station configuration incorporating the MTFF. O.C.

A88-35074

REPORT OF THE NATIONAL COMMISSION ON SPACE - ONE COMMISSIONER'S VIEW

JACK L. KERREBROCK (MIT, Cambridge, MA) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 435-440.
(AAS PAPER 86-250)

The National Commission on Space has recommended a tripling of the NASA R&D budget, as well as the aggressive development of seven critical technology-demonstration fields: (1) flight research on aerospaceplane aerodynamics and propulsion; (2) advanced rocket technologies; (3) aerobraking maneuvers; (4) long-duration, closed ecosystems; (5) electric propulsion systems; (6) nuclear-electric space power, and (7) space tethers and artificial gravity. Attention is given to the unique consequentiality of scramjet propulsion development for airbreathing launch vehicle propulsion to speeds above Mach 20. O.C.

A88-35075* National Aeronautics and Space Administration, Washington, DC.

THE SPACE STATION AND RECOMMENDATIONS OF THE NATIONAL COMMISSION ON SPACE

E. LEE TILTON (NASA, Washington, DC) and THEODORE R. SIMPSON (General Research Corp., McLean, VA) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 441-446.
(AAS PAPER 86-263)

The planned NASA Space Station, and its associated orbit transfer vehicle, are only the first of a series of Space Stations and transfer vehicles that the United States will need to pioneer the space frontier in the 21st century. The initial station and transfer vehicle will develop some of the technology and systems needed for follow-on stations, vehicles, and bases on the moon and Mars. Author

A88-35081

UPDATE ON SOVIET SPACE ACTIVITIES

MARCIA S. SMITH (U.S. Library of Congress, Washington, DC) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 479-483.
(AAS PAPER 86-466)

It is noted that the assertion in the 1988 Jane's Spaceflight Directory that the USSR is as much as 10 years ahead of the USA in space technology development may not be generally justified, but is at least arguable in the specific field of manned space operations in earth orbit. Through their space station program, which began in 1971, the Soviets have gained considerable experience in the operation of large platforms and ferry spacecraft, the repair of orbiting spacecraft and their refueling, and the performing of experiments in space conditions. O.C.

A88-35115* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

LARGE SPACE SYSTEMS REQUIREMENTS, DEPLOYABLE CONCEPTS, AND TECHNOLOGY ISSUES

U. M. LOVELACE and L. B. GARRETT (NASA, Langley Research Center, Hampton, VA) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1019-1034. refs
(AAS PAPER 86-394)

This paper summarizes some of the future civil missions requiring large space systems technologies. Antenna, collector, and reflector missions are generalized to define a similar set of system requirements and characteristics. Although many concepts exist for both deployable and space assemblable large structures, four technically mature deployable concepts are reviewed. Two of these concepts are probably applicable to only antenna/collector missions, whereas the other two employ continuous trusses which can be configured for a broad range of planar, linear, or curved structures. Finally, technology problems or needs associated with large deployable systems are reviewed to highlight additional research and development, both analytical and experimental, required to reduce mission risk. Author

A88-35131

TRANSITIONING FROM SPACELAB TO SPACE STATION SCIENCE

BYRON K. LICHTENBERG (Payload Systems, Inc., Wellesley, MA) IN: Aerospace century XXI: Space sciences, applications, and commercial developments; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1279-1286. (AAS PAPER 86-284)

Space science operations issues are discussed with respect to both the current capabilities of the Spacelab portion of the National Space Transportation System and future requirements for operation of the Space Station. The capabilities and weaknesses of Spacelab are illustrated with examples from the first four flights. Projected operations scenarios for the Space Station are considered, emphasizing the need for system flexibility. Suggestions for the Space Station development include the use of 'telescience' to maximize the efficient use of the crew and the ground investigator team, and the continuation of ground-based experiments and data analysis on archived data. R.R.

A88-35877

THE ENVIRONMENT OF EARTH-ORBITING SYSTEMS

H. HAMACHER (DFVLR, Institut fuer Raumsimulation, Cologne, Federal Republic of Germany), B. FITTON (Leiden, Rijksuniversiteit, Sterrewacht, Netherlands), and J. KINGDON (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: Fluid sciences and materials science in space: A European perspective. Berlin and New York, Springer-Verlag, 1987, p. 1-50. refs

The environment encountered by earth-orbiting spacecraft is characterized with particular reference to microgravity experimentation. A number of disturbances resulting in accelerations that prevent from achieving ideal zero-gravity conditions in spacecraft are identified, and the most dominant disturbances are discussed. Particular attention is given to the gravitational enviroment of Spacelab and the planned Space Station. The discussion also covers the effects of radiation, atmospheric conditions, high-energy particles, and electric and magnetic fields. V.L.

A88-36556

COSM: A SPACE STATION EVAS TEST CHALLENGE

FRANK A. PULLO and ANTHONY C. BEARDSLEY (Grumman Corp., Aircraft Div., Bethpage, NY) IN: AUTOTESTCON '87; Proceedings of the International Automatic Testing Conference, San Francisco, CA, Nov. 3-5, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 221-226.

The authors present the requirements that must be addressed to develop equipment that will perform the checkout, servicing, and maintenance (COSM) of the extravehicular activity system (EVAS) for manned space on the proposed US Space Station. An overview is presented of COSM operational requirements, and their relationship to an automatic COSM system. The Space Station environment, routine EVA sorties, and singular mission objectives and tasks are examined with respect to system design. The COSM system architecture and the technical approach taken are also examined. I.E.

A88-37257#

THE FLINDERS PLATFORM - A LOW-COST MULTIMISSION PLATFORM FOR AUSTRALIA

M. L. PFITZNER (AUSPACE, Ltd., Australia) IN: National Space Engineering Symposium, 3rd, Canberra, Australia, June 30-July 2, 1987, Preprints of Papers. Barton, Australia/Brookfield, VT, Institution of Engineers/Brookfield Publishing Co., 1987, p. 111-115.

The 'Flinders' 3-axis stabilized orbiting platform presently discussed is relatively small and derives its modest cost from the incorporation of several previously developed subsystems. Flinders is compatible with several Ariane-4 upper stage configurations, and can be applied to a range of orbits, from LEO to GEO. Its possible missions extend to earth observation, mobile communications, astronomical and magnetospheric research, and domestic telecommunications. O.C.

A88-37398*# General Electric Co., Philadelphia, PA.

POTENTIAL GPS USER ARCHITECTURE FOR THE NASA SPACE STATION BASED ON LANDSAT 4/5 EXPERIENCE

DAVID A. KORENSTEIN (General Electric Co., Astro-Space Div., Philadelphia, PA) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 171-175. refs (Contract NAS5-25300)

A Landsat 4/5 GPS system is described which uses an inertial reference attitude control system and precision real-time ephemeris generation to achieve precision earth pointing. The system has application to the validation of the use of GPS for the low earth orbit navigation of the Space Station. The present system consists of a receiver/processor assembly (R/PA), an L-band GPS antenna, a precision oscillator, and the Landsat computer. The R/PA is integrated with a GPS receiver which selects, acquires, tracks, times, and decodes navigation signals from GPS satellites in order to derive ephemerides. Ephemeris estimates were found to be accurate to better than 50 meters. R.R.

A88-39077

THE INFRARED SPACE OBSERVATORY (ISO) PROJECT

M. F. KESSLER (ESA, Space Science Dept., Noordwijk, Netherlands) IN: Planetary and proto-planetary nebulae: From IRAS to ISO; Proceedings of the Frascati Workshop, Vulcano Island, Italy, Sept. 8-12, 1986. Dordrecht, D. Reidel Publishing Co., 1987, p. 261-268; Discussion, p. 268, 269.

The ISO, an approved and funded project of ESA, is an astronomical satellite which will operate at wavelengths from 3 to 200 microns. Its cryogenically cooled 60-cm telescope will be equipped with four complementary and versatile focal-plane instruments, which will enable imaging and also photometric, spectroscopic, and polarimetric observations. These instruments are being built by international consortia of scientific institutes and will be delivered to ESA for in-orbit operations. The expected launch date is 1993, and the in-orbit lifetime will be at least 18 months. In keeping with ISO's role as an observatory, two-thirds of its observing time will be made available to the general astronomical community. Author

A88-39332

WESTERN EUROPEAN SPACE SCIENCE

IAN AXFORD (Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau, Federal Republic of Germany) Physics Today (ISSN 0031-9228), vol. 41, May 1988, p. 42-52.

An account is given of the national and ESA-coordinated space science research efforts of the West European countries to date, including the substantial portion of these undertaken in collaboration with NASA, such as the Exosat, COS-B, Geos, and ISEE satellites. Program origins, goals, and achievements are discussed for the cases of SPOT, Giotto, Hipparcos, the IUE, Ulysses, Galileo, Rosat, the IR Space Observatory, and the European Retrievable Carrier. Longer-term plans encompass a Solar-Terrestrial Science Program, a Comet Nucleus Sample Return Mission, the Quasat VLBI worldwide network, and the Cassini Saturn probe. O.C.

A88-40571

AN ENERGETICS EXPERIMENT ON A SPACE PLATFORM

KYOICHI KURIKI (Tokyo, University, Sagamihara, Japan) and HIROAKI OBARA (Mitsubishi Electric Corp., Tokyo, Japan) Space Power (ISSN 0951-5089), vol. 7, no. 1, 1988, p. 75-89. refs

This paper discusses the Space Flyer Unit (SFU) free-flying platform and the on-board advanced-technology experiments planned for this system in relation to the Space Power Satellite (SPS) technology. Attention is given to the design of the SFU and payload integration, the energy-exploitation experiments, and to interactive experiments between SFU and SPS. Special consideration is given to the configuration and characteristics and the experimental objectives of a two-dimensionally deployable array and a high-voltage solar array and to electric propulsion experiment, microwave energy transmission experiment, and space experiment with particle accelerators. Design diagrams of the SFU and the various experiments designed for it are included. I.S.

A88-43299*#

SPACECRAFT TECHNOLOGY REQUIREMENTS FOR FUTURE NASA MISSIONS

WAYNE R. HUDSON and GORDON I. JOHNSTON (NASA, Washington, DC) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 10 p. refs
(AIAA PAPER 88-3487)

By working with advanced planners in the NASA Office of Space Science and Applications (OSSA), a spacecraft technology model has been generated that represents the predominant themes of their respective programs for the next twenty years. This set of missions serves as a base from which a few representative and challenging landmark missions have been extracted to serve as a focal point for identifying the most critical technology issues. Each mission requires significant advances in several technology disciplines in order to be feasible. The mission set selected to serve as a technology focus reflects the increased emphasis within NASA on a potential civil space leadership initiative, and include the Geostationary Earth Observing PLatform from the Planet Earth initiative and the precursor Mars Rover and Sample Return mission from the Mars Exploration Initiative. These missions are briefly described and the key technology requirements are discussed. Author

A88-43964#

A DESCRIPTION OF THE EXPANDABLE PLATFORM

JOSEPH J. MANGAN (Aerospace Industries Association of America, Inc., Washington, DC) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 140-147.

The five regular convex polyhedrons, or Platonic solids, are presently used as the geometrical bases of structural frames that can be selected, assembled, and located by computers; they essentially represent redundant shapes that can be expanded or contracted, and are programmed for robotic construction. An account is given of how structural frames predicated on the five solids can be used on the moon and on Mars to solve numerous problems encountered in lunar and planetary base design and in their high speed transportation systems. O.C.

A88-43968#

THE SPACE PHOENIX PROGRAM - A PROGRESS REPORT

T. F. ROGERS (External Tanks Corp., Boulder, CO) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 171-174.

The primary concern of the Space Phoenix Program is the beneficiation of the discarded, orbiting external tanks (ETs) of the Space Shuttle in order to transform them into safe, sanitary and durable habitable space structures whose volume will be made available to commercial users on a leasing basis. The program is currently drawing upon the interests and capabilities of over 50 universities, in active cooperation with U.S. agencies, and has chosen as its first objective the creation of a general-purpose scientific research facility, 'Labitat', using aforementioned Space Shuttle ETs, in which scientists will be able to both reside and work. O.C.

A88-44150

THE U.S. SPACE STATION - A QUARTER-CENTURY OF EVOLUTION

PHILIP D. HATTIS (Charles Stark Draper Laboratory., Inc., Cambridge, MA) Technology Review (ISSN 0040-1692), vol. 91, July 1988, p. 28-40.

In October, 1986, NASA Langley's Critical Evaluation Task Force recommended that the Space Station be built in two phases. The relatively modest Phase I station would encompass the central horizontal truss of the dual-keel model, together with all pressurized modules; this would entail 19 Space Shuttle flights over three years. Phase II, for which funding approval would be sought only after substantial progress toward launching Phase I, would use six additional Shuttle flights to put the full dual-keel Space Station configuration in operating order. As Phase I is embarked upon, major programmatic questions remain as to the intersection of military and international interests in the Space Station's design and use. O.C.

A88-44613

NASA'S PATHFINDER PLOTS FUTURE US SPACE ACTIVITIES

ANDREW WILSON Interavia (ISSN 0020-5168), vol. 43, June 1988, p. 591-593.

NASA's $850-million 'Pathfinder' project has as its goal the definition and development of generic technologies for future missions beyond earth orbit; these are grouped under the categories of 'exploration', 'operations', 'transfer vehicles', and 'human life support'. Pathfinder will attempt to define advanced capabilities for both manned and unmanned ventures, of which the latter may be typified by a Mars sample-return mission by 1998. A Mars mission would entail substantial development of such techniques as aerobraking, in order to reduce spacecraft earth departure masses by up to 50 percent, as well as electric propulsion and controlled-environment life-support systems. O.C.

A88-44741#

THE GAMMA RAY OBSERVATORY (GRO) PROPULSION SUBSYSTEM

J. A WEATHERLY, R. A. CARLSON, and S. C. HEVERT (TRW, Inc., Space and Technology Group, Redondo Beach, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p.
(AIAA PAPER 88-3051)

The Gamma Ray Observatory (GRO) LEO spacecraft's Propulsion Subsystem (PSS) is a large, hydrazine monopropellant system containing over 4000 lbs of fuel to furnish ascent, drag compensation, three-axis stabilization, and controlled reentry power. The PSS uses four 100-lb thrust engines for orbital adjustment and eight 5-lb thrust engines for attitude control. GRO is the first NASA spacecraft to be designed to take advantage of a standardized refueling coupling for on-orbit refueling. O.C.

A88-48477*# Martin Marietta Corp., Denver, CO.

TRANSPORTATION CONCEPTS FOR MARS EXPLORATION

BENTON C. CLARK (Martin Marietta Planetary Sciences Laboratory, Denver, CO) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 7 p. refs
(Contract NAS8-37126)
(AIAA PAPER 88-3494)

The transportation aspects of astronaut travel to Mars are discussed. Alternative types of propulsion are examined, including mainline and ancillary chemical propulsion, electric propulsion, and nuclear thermal rocket propulsion. The possibility of remote propellant production is presented, focusing on the use of lunar liquid oxygen, Phobos propellants and Mars propellant production. Also, the way in which habitat models may be derived from Space Station modules or from other designs capitalizing on larger diameter payload envelopes for heavy-lift launch vehicles is considered. R.B.

A88-49820#

THE EUROPEAN LONG-TERM SPACE PLAN

K.-E. REUTER (ESA, Coordination and Monitoring Office, Paris, France) ESA Bulletin (ISSN 0376-4265), no. 54, May 1988, p. 14-29.

A recent proposal for a coherent European space program for the 1990s and beyond is outlined. The proposed scientific program includes solar terrestrial science research, missions to asteroids and comets, and a spectroscopic observatory for X-ray sources. The earth observing program will involve the use of polar orbiting systems for studying ice, the ocean, coastal processes, and meteorology. The microgravity research program, including the Man-Tended Free Flyer and Eureca, and the telecommunications program are also considered. Other topics discussed include the Space Station and space platforms programs, the space-transportation program, space infrastructure operations, the future ground infrastructure, and organizational and budgetary considerations. R.R.

A88-51133
SPACE FOR RENT?
ANDREW LAWLER Space World (ISSN 0038-6332), vol. Y-9-297, Sept. 1988, p. 15-19.

Plans to build an industrial space facility which would consist of a manned, free-flying platform and would be serviced by the Shuttle are discussed. The plan was sponsored by the Space Industries Partnerships, made up of several private aerospace companies. Efforts to gain governmental support for the project are examined, and the possiblities for the future of the plan are considered. R.B.

A88-51715#
PROBLEMS AND SOLUTIONS FOR GPS USE BEYOND THE 12-HOUR ORBIT
STANLEY C. MAKI (General Dynamics Corp., Space Systems Div., San Diego, CA) IN: Institute of Navigation, National Technical Meeting, Santa Barbara, CA, Jan. 26-29, 1988, Proceedings. Washington, DC, Institute of Navigation, 1988, p. 187-193. refs

Eight different technological approaches for improving availability of GPS satellites at GEO are evaluated. These approaches are high-gain antenna systems, GPS channel coding, low-noise preamp, filter optimization, GPS satellite acquisition and selection, accurate on-board clock, mission planning, and earth-based GPS transmitters. Three options which stand out as possible solutions are analyzed and simulated: the combination of a high-gain antenna system with an accurate on-board clock, the use of earth-based GPS transmitters, and filter optimization. Performance improvement results and implementation are presented. C.D.

A88-52332
TECHNOLOGY DEVELOPMENT MISSIONS CONCEPT DEFINITION STUDY - TDMX 2066 LARGE INFLATABLE/RIGIDIZED STRUCTURES
R. E. GIUNTINI and K. M. SEISER (Wyle Laboratories, El Segundo, CA) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-9 to 5-20.

A preliminary study is presented for a technology development mission (TDMX 2066) to address the definition, feasibility, and requirements for a large inflatable/rigidized hangar for payload servicing on the Space Station. The applications and technology options for inflatable/rigidized structures are examined, including Space Shuttle enhancements, Space Station elements, orbital transfer and satellite systems, and lunar habitats. The concept design, ground logistics, and support requirements for development of the hangar are discussed. STS flight requirements, on-orbit logistics/support resource requirements, and a preliminary evolutionary plan indicating the phases from development to Space Station flight are given. R.B.

A88-52337
A RESUPPLY SCENARIO FOR THE COLUMBUS MANTENDED FREEFLYER (MTFF)
H. J. C. KOOPMANN (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-63 to 5-76.

The processes involved in the resupply system for the Columbus Man-tended Free Flyer (MTFF) are discussed. The design characteristics of the MTFF pressurized laboratory module and the resource module are examined. Aspects of the MTFF operations concept are described, including launch and initial activation, mission orbit profile, routine operations, servicing, and rendezvous and proximity operations. MTFF in-orbit servicing tasks and requirements are presented. Upload assessments for Hermes and the Space Station and the processes involved in resupply scenarios are presented. R.B.

A88-52362* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ORBITAL MANEUVERING VEHICLE SUPPORT TO THE SPACE STATION
WILLIAM E. GALLOWAY (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 10-1 to 10-7.

This paper describes the Orbital Maneuvering Vehicle (OMV) and its intended role as a key element of the National Space Transportation System. Various types of missions, operating modes, and performance capabilities for the OMV are described as are typical mission scenarios, with the OMV based at the Shuttle and at the Space Station (SS). Particular emphasis is placed on OMV missions in support of the SS. Retrieval of a spacecraft to the SS for servicing, followed by redeployment of the spacecraft to its operational orbit is typical of SS-based projected missions. Author

A88-53221* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE SUPERFLUID HELIUM ON-ORBIT TRANSFER (SHOOT) FLIGHT EXPERIMENT
MICHAEL J. DIPIRRO (NASA, Goddard Space Flight Center, Greenbelt, MD) and PETER KITTEL (NASA, Ames Research Center, Moffett Field, CA) IN: Advances in cryogenic engineering. Volume 33 - Proceedings of the Cryogenic Engineering Conference, Saint Charles, IL, June 14-18, 1987. New York, Plenum Press, 1988, p. 893-900. refs

The SHOOT flight demonstration is being undertaken to verify component and system level technology necessary to resupply large superfluid helium dewars in space. The baseline configuration uses two identical 210 liter dewars connected by a transfer line which contains a quick disconnect coupling. The helium will be transferred back and forth between the dewars under various conditions of flow rate, parasitic heat load, and temperature. An astronaut Extra-vehicular Activity (EVA) is also planned to manually demate and mate the coupling. A number of components necessary for the flight are being developed. These components are described here. Author

A88-53666*# Stanford Univ., CA.
TELESCIENCE TESTBED PILOT PROJECT - EVALUATION ENVIRONMENT FOR SPACE STATION OPERATIONS
MICHAEL J. WISKERCHEN (Stanford University, CA) and BARRY M. LEINER (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA, Flight Simulation Technologies Conference, Atlanta, GA, Sept. 7-9, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 319-324. (AIAA PAPER 88-4629)

The objectives of the Telescience Testbed Pilot Program (TTPP) are discussed. The purpose of the TTPP, which involves 15 universities in cooperation with various NASA centers, is to demonstrate the utility of a user-oriented rapid prototyping testbed approach to developing and refining science requirements and validation concepts and approaches for the information systems of the Space Station era and beyond. It is maintained that the TTPP provides an excellent environment, with low programmatic schedule and budget risk, for testing and evaluating new operations concepts and technologies. K.K.

A88-54573* Control Dynamics Co., Huntsville, AL.
ACES PROGRAM - LESSONS LEARNED
VICTORIA L. JONES, SALLY C. RICE (Control Dynamics Co., Huntsville, AL), and HENRY B. WAITES (NASA, Marshall Space Flight Center, Huntsville, AL) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1453-1455.

The ACES Program involved the experimental evaluation of three LSS (large space structures) control design techniques at the LSS GTF (ground test facility) at NASA/MSFC. The three techniques were developed under the ACOSS (active control of space structures) Program specifically for application to LSS. The techniques included FAMESS (filter accommodated model error sensitivity suppression), HAC/LAC (high authority control/low authority control), and positivity. Some of the lessons that have been learned during the course of the ACES program are examined. I.E.

A88-54603
ON THE CALTECH EXPERIMENTAL LARGE SPACE STRUCTURE
GARY J. BALAS and JOHN C. DOYLE (California Institute of Technology, Pasadena) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1701, 1702. Research supported by California Institute of Technology and TRW, Inc.

A large-space-structure experiment developed at the California Institute of Technology is reported. The main thrust of the experiment is to address the identification and robust control issues associated with large space structures by capturing their characteristics in the laboratory. The design, modeling, identification, and control objectives are discussed. I.E.

A88-54851*# National Aeronautics and Space Administration, Washington, DC.
GETTING READY TO GO
THOMAS L. MOSER (NASA, Space Station Program Office, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 26, Sept. 1988, p. 16-18.

The reevaluation of the Space Station that has occurred over the past two and a half years is reviewed, and the system development that has been recently initiated is discussed. Upcoming developments with regard to laboratory outfitting, extended duration Orbiter, and logistics operations are summarized. The goals of the first launches are discussed, and the aims of the succeeding manned flights are examined. C.D.

A88-55314#
DEMONSTRATION MISSION ON COLUMBUS FOR TECHNOLOGY DEVELOPMENTS
J. PULS (DFVLR, Oberpfaffenhofen, Federal Republic of Germany) and D. KASSING (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p.
(IAF PAPER 88-002)

The paper deals with the description of technology demonstration missions identified in the European Columbus utilization program. The candidate payloads represent new technologies needed to upgrade the autonomous operational capabilities of the Columbus/ISS infrastructure. The in-orbit demonstration is justified in order to reduce the development risk before the concept is frozen and by the fact that special technical properties cannot be investigated on ground. A survey on the development status is given with an outlook to future activities coordinated by ESA. Author

A88-55322*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TECHNOLOGY FORECAST AND APPLICATIONS FOR AUTONOMOUS, INTELLIGENT SYSTEMS
HENRY LUM, JR. (NASA, Ames Research Center, Moffett Field, CA) and EWALD HEER (Heer Associates, Inc., LaCanada, CA) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 10 p. refs
(IAF PAPER 88-025)

Significant research products which have emerged from the core program of NASA's Office of Aeronautics and Space Technology (OAST) are discussed. The Space Station Thermal Control System, the Space Shuttle Integrated Communications Officer, Station, the Launch Processing System, the Expert Scheduling System for Pioneer Venus Spacecraft, a Bayesian classification system, and a spaceborne multiprocessor system are included. The technology trends which led to these results are discussed and future developments in technology are forecasted. R.B.

A88-55337#
THE MANNED SPACE LABORATORIES CONTROL CENTER (MSCC) AT DFVLR - OBERPFAFFENHOFEN, GERMANY
J. KEHR and K. REINEL (DFVLR, Oberpfaffenhofen, Federal Republic of Germany) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 18 p.
(IAF PAPER 88-087)

The development of an operations concept for manned laboratories is discussed. European space programs are outlined, stressing the Columbus program. The European ground based operations centers and the operational management structure for the ESA are examined. The activities of the Manned Space Laboratories Control Center (MSCC) are described, including planning manned flights, systems and payload operations, and ground support. The three test facilities for in-orbit operations within the MSCC are the European Proximity Operation Simulation Facility, a servicing test facility, and a test facility for large flexible spacecraft control. R.B.

A88-55340#
COLUMBUS PRESSURIZED MODULES - A VERSATILE USER-FRIENDLY SPACE LABORATORY SYSTEM
E. VALLERANI, L. D'EMILIANO, and D. BOGGIATTO (Aeritalia S.p.A., Turin, Italy) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 11 p.
(IAF PAPER 88-097)

The design and features of the Columbus Pressurized Modules (PMs) are presented. The architecture of the PMs are described and illustrated. Racks to house subsytem equipment and payloads, locations for internal maintenance performance, payload accommodation, and resource availability are examined. Also, the roles of the module control station and the general purpose work bench in systems and payload operations support are discussed. R.B.

A88-55417#
MULTIMISSION COMMUNICATION SATELLITES
FRANCOIS PANZANI, JACQUES THUERY, and DENIS ROUFFET (Alcatel Espace, Toulouse, France) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 11 p.
(IAF PAPER 88-426)

The constant availability of new space techniques and technologies has made the design of flexible, multimission satellites possible. This paper discusses the resulting multiplicity of services, and gives user and designer criteria which must be respected in order to make such services viable. Techniques that permit using a single satellite for several different missions by providing the required reconfiguration flexibility are examined. Finally, the French National Telecom 2 satellite, which is an excellent example of a multimission system, is described. C.D.

A88-55454#
LUNAR ORBIT SERVICE STATION
H. HERMANN KOELLE (Berlin, Technische Universitaet, Federal Republic of Germany) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 5 p. refs
(IAF PAPER 88-618)

Facts and arguments supporting an early establishment of a manned lunar orbiting service station are presented. Ten specific functions of such a facility are defined, and the characteristics of a 50 km altitude lunar orbit are summarized. Twelve elements and subsystems comprising such a service station are given, and some of the design options are mentioned. A list of 17 system criteria enabling the designer, planner, and decision maker to compare alternatives in a rational way to arrive at an optimal solution for the development scenario is presented. C.D.

N88-20330# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Div. Systems Strategiques et Spatiaux.
STUDY ON LONG TERM EVOLUTION TOWARDS EUROPEAN AUTONOMOUS MANNED SPACEFLIGHT (STEAMS) Final Report
M. GRIMARD Paris, France ESA 22 Jun. 1987 169 p
(Contract ESTEC-6668/86-NL-PP)
(SNIAS-SE/LS/AP-35-073; ESA-CR(P)-2520; ETN-88-91962)
Avail: NTIS HC A08/MF A01

It is shown that a medium sized European space station (ESS) is achievable before 2010. This ESS should allow a permanent occupation by 2 to 4-men crews with a 3 months crew exchange cycle. Manned missions should focus on life sciences, materials, and bioprocessing. A coorbiting platform is required for processing in high quality microgravity environment. It will be a Columbus Man Tended Free Flyer or EURECA derivative. The polar infrastructure is independent of LEO manned one (only hardware commonality). Crew safety is a prime driver for the manned ESS and an escape means permanently docked at the station is required: a dedicated Escape Vehicle or Hermes if it can stay docked for a long time. The logistics support of ESS requires a combined use of Hermes and Ariane 5 flights. This implies high costs for the operations due to launch costs (2 to 4 Hermes flights per year and 1 Ariane 5 flight every 9 to 12 months). This first generation ESS does not allow efficient and intensive commercial activities because of the high operational costs. The reduction of these requires the introduction of new launching systems and the implementation in parallel of a 2nd generation manned infrastructure which might be foreseen in the post-2010 years. ESA

N88-20339*# Martin Marietta Corp., Denver, CO. Astronautics Group.
ORBITAL TRANSFER VEHICLE CONCEPT DEFINITION AND SYSTEM ANALYSIS STUDY. VOLUME 2: OTV CONCEPT DEFINITION AND EVALUATION. BOOK 1: MISSION AND SYSTEM REQUIREMENTS Final Report, Jul. 1984 - Oct. 1985
ALLEN E. KOFAL Jul. 1987 70 p Revised
(Contract NAS8-36108)
(NASA-CR-179321; NAS 1.26:179321; MCR-86-2601-VOL-2-BK-1)
Avail: NTIS HC A04/MF A01 CSCL 22B

The mission and system requirements for the concept definition and system analysis of the Orbital Transfer Vehicle (OTV) are established. The requirements set forth constitute the single authority for the selection, evaluation, and optimization of the technical performance and design of the OTV. This requirements document forms the basis for the Ground and Space Based OTV concept definition analyses and establishes the physical, functional, performance and design relationships to STS, Space Station, Orbital Maneuvering Vehicle (OMV), and payloads. Author

N88-21190*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A 60-METER ERECTABLE ASSEMBLY CONCEPT FOR A CONTROL OF FLEXIBLE STRUCTURES FLIGHT EXPERIMENT
JUDITH J. WATSON and WALTER L. HEARD, JR. Feb. 1988 20 p
(NASA-TM-100497; NAS 1.15:100497) Avail: NTIS HC A03/MF A01 CSCL 22B

A flight experiment which proposes to use a 60-m deployable/retractable truss beam attached to the Space Shuttle to study dynamic characterization and control of flexible structures is being studied by NASA. The concept requires a relatively complex mechanism for deploying and retracting the truss on-orbit. Development of such a mechanism having a high degree of reliability will be expensive. An alternative method for constructing the truss is discussed requiring no new technology development or complex mechanisms and has already been demonstrated on-orbit. The alternative method proposes an erectable truss beam which can be assembled by two astronauts in EVA. The EVA crew would have to manually assemble the beam from 468 struts and 165 nodes, and install 7 instrumentation platforms with signal and power cabling. The predicted assembly time is 3 hr and 23 min. The structure would also have to be disassembled and restowed following testing, thus 2 EVA days would be required. To allow 25 hr for data collection (probably a bare minimum to accomplish meaningful tests), current Shuttle operations policy dictates a 9-day mission. The design, assembly procedure and issues associated with the alternative concept are discussed. Author

N88-23826*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LDR STRUCTURAL EXPERIMENT DEFINITION
RICHARD A. RUSSELL and RICHARD M. GATES (Boeing Aerospace Co., Seattle, Wash.) Jun. 1988 51 p
(NASA-TM-100618; NAS 1.15:100618) Avail: NTIS HC A04/MF A01 CSCL 22B

A study was performed to develop the definition of a structural flight experiment for a large precision segmented reflector that would utilize the Space Station. The objective of the study was to use the Large Deployable Reflector (LDR) baseline configuration for focusing on experiment definition activity which would identify the Space Station accommodation requirements and interface constraints. Results of the study defined three Space Station based experiments to demonstrate the technologies needed for an LDR type structure. The basic experiment configurations are the same as the JPL baseline except that the primary mirror truss is 10 meters in diameter instead of 20. The primary objectives of the first experiment are to construct the primary mirror support truss and to determine its structural and thermal characteristics. Addition of the optical bench, thermal shield and primary mirror segments and alignment of the optical components occur on the second experiment. The structure will then be moved to the payload pointing system for pointing, optical control and scientific optical measurement for the third experiment. Author

N88-23828* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE SPIDER CRANE Patent
IAN O. MACCONOCHIE, inventor (to NASA), MARTIN M. MIKULAS, JR., inventor (to NASA), JACK E. PENNINGTON, inventor (to NASA), REBECCA L. KINKEAD, inventor (to NASA), and CHARLES F. BRYAN, JR., inventor (to NASA) 19 Apr. 1988 13 p Filed 30 Sep. 1986 Supersedes N87-15259 (25 - 07, p 874)
(NASA-CASE-LAR-13411-1-SB; US-PATENT-4,738,583; US-PATENT-APPL-SN-913432; US-PATENT-CLASS-414-735; US-PATENT-CLASS-414-750; US-PATENT-CLASS-901-1; US-PATENT-CLASS-901-33; US-PATENT-CLASS-180-8.6) Avail: US Patent and Trademark Office CSCL 22B

A space spider crane for the movement, placement, and or assembly of various components on or in the vicinity of a space structure is described. As permanent space structures are utilized by the space program, a means will be required to transport cargo and perform various repair tasks. A space spider crane comprising a small central body with attached manipulators and legs fulfills this requirement. The manipulators may be equipped with constant pressure gripping end effectors or tools to accomplish various repair tasks. The legs are also equipped with constant pressure gripping end effectors to grip the space structure. Control of the space spider crane may be achieved either by computer software or a remotely situated human operator, who maintains visual contact via television cameras mounted on the space spider crane. One possible walking program consists of a parallel motion walking program whereby the small central body alternatively leans forward and backward relative to end effectors.
Official Gazette of the U.S. Patent and Trademark Office

N88-26397*# Bionetics Corp., Hampton, VA.
SOME OPERATIONAL ASPECTS OF A ROTATING ADVANCED-TECHNOLOGY SPACE STATION FOR THE YEAR 2025 Contractor Report, May - Nov. 1987
M. J. QUEIJO, A. J. BUTTERFIELD, W. F. CUDDIHY, C. B. KING, R. W. STONE, J. R. WROBEL, and P. A. GARN Jun. 1988 313 p
(Contract NAS1-18267)
(NASA-CR-181617; NAS 1.26:181617) Avail: NTIS HC A14/MF A01 CSCL 22B

The study of an Advanced Technology Space Station which would utilize the capabilities of subsystems projected for the time frame of the years 2000 to 2025 is discussed. The study includes tradeoffs of nuclear versus solar dynamic power systems that produce power outputs of 2.5 megawatts and analyses of the dynamics of the spacecraft of which portions are rotated for artificial gravity. The design considerations for the support of a manned Mars mission from low Earth orbit are addressed. The studies extend to on-board manufacturing, internal gas composition effects, and locomotion and material transfer under artificial gravity forces. The report concludes with an assessment of technology requirements for the Advanced Technology Space Station. Author

N88-27180*# Axiomatix, Los Angeles, CA.
SPACECRAFT APPLICATIONS OF ADVANCED GLOBAL POSITIONING SYSTEM TECHNOLOGY Final Report
GAYLORD HUTH, JAMES DODDS, SERGEI UDALOV, RICHARD AUSTIN, PETER LOOMIS, and I. NEWTON DUBORAW, III (Motorola, Inc., Chicago, Ill.) 31 May 1988 147 p
(Contract NAS9-17681)
(NASA-CR-172055; NAS 1.26:172055; R8805-5) Avail: NTIS HC A07/MF A01 CSCL 17G

The purpose of this study was to evaluate potential uses of Global Positioning System (GPS) in spacecraft applications in the following areas: attitude control and tracking; structural control; traffic control; and time base definition (synchronization). Each of these functions are addressed. Also addressed are the hardware related issues concerning the application of GPS technology and comparisons are provided with alternative instrumentation methods for specific functions required for an advanced low earth orbit spacecraft. B.G.

N88-29849# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France).
INTERIM FLIGHT OPPORTUNITY (IFO). VOLUME 1: EXECUTIVE SUMMARY Final Report
M. H. AENISHANSLIN Paris, France ESA 16 Dec. 1987 65 p Prepared in cooperation with Construcciones Aeronauticas S.A., Madrid, Spain, Saab Space A.B., Goeteborg, Sweden, Erno Raumfahrttechnik G.m.b.H., Bremen, West Germany, Norsk Forsvarsteknologi A/S, Norway, Sener S.A., Madrid, Spain, and Fokker B.V.
(Contract ESA-6272/85-NL-AB)
(SE/LS/AP-36-818/CN-VOL-1; ESA-CR(P)-2583-VOL-1; COL-TN-AS-0059-VOL-1; ETN-88-93028) Avail: NTIS HC A04/MF A01

A space platform for a wide variety of missions prior to Columbus space station availability is proposed. It can be launched as spare capacity or as main payload on different launchers into a variety of orbits, where it circles for a limited time and then a subset or the whole reenters in a controlled way for recovery on ground. The general configuration is composed of two separable elements: an expendable part, the bus, and a reentry vehicle (REV). Maximum diameter for the bus is 2 m to have an easy and feasible accommodation on a wide variety of launchers. The REV is dimensioned to be able to provide a payload dedicated volume greater than 0.2 cum and the global mass of the platform is not greater than 1500 kg. The BUS is conceived for two alternatives: a battery powered baseline for a ten-day mission, and an option with solar arrays for a 1-month mission. Subsystems are: structure, thermal control, electrical power, attitude control, data handling, communication, and mechanisms. The REV is composed of separable units: a propulsion module and a reentry capsule. The subsystem list is similar to the bus with propulsion and recovery systems added. ESA

N88-29850*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE STRUCTURE (DYNAMICS AND CONTROL) THEME DEVELOPMENT
RICHARD A. RUSSELL and RICHARD M. GATES (Boeing Aerospace Co., Seattle, Wash.) Aug. 1988 32 p
(NASA-TM-100597; NAS 1.15:100597) Avail: NTIS HC A03/MF A01 CSCL 22B

A study was made to define the long-range technical objectives and goals for the Space Structure (Dynamics and Control) theme area. The approach was to evaluate ongoing and proposed technology activities such that the technology gaps and voids could be identified. After the technology needs were identified, a set of recommended experimental activities was defined including the technical objectives of each and their relationship. Author

N88-29856*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DEFINITION OF COMMON SUPPORT EQUIPMENT AND SPACE STATION INTERFACE REQUIREMENTS FOR IOC MODEL TECHNOLOGY EXPERIMENTS
RICHARD A. RUSSELL and RICHARD D. WAISS (Boeing Aerospace Co., Seattle, Wash.) Aug. 1988 163 p
(NASA-TM-100656; NAS 1.15:100656) Avail: NTIS HC A08/MF A01 CSCL 22B

A study was conducted to identify the common support equipment and Space Station interface requirements for the IOC (initial operating capabilities) model technology experiments. In particular, each principal investigator for the proposed model technology experiment was contacted and visited for technical understanding and support for the generation of the detailed technical backup data required for completion of this study. Based on the data generated, a strong case can be made for a dedicated technology experiment command and control work station consisting of a command keyboard, cathode ray tube, data processing and storage, and an alert/annunciator panel located in the pressurized laboratory. Author

N88-30447# European Space Agency, Paris (France).
WITH AN EYE TO THE FUTURE: ESA GENERAL STUDIES PROGRAM 1988
NORMAN LONDDON, ed. and BRIGITTE KALDEICH, ed. Apr. 1988 38 p Original contains color illustrations
(ESA-SP-1100; ISSN-0250-1589; ETN-88-93047) Avail: NTIS HC A03/MF A01

The ESA programs concerning end-to-end telematics architecture; long-term evolution of telecommunications services and systems; long-term evolution of Earth observation; microgravity utilization; autonomous orbital capability architecture; in-orbit assembly, servicing, and tending; long-term evolution of space transportation systems; and European ground infrastructure are presented. ESA

02

ANALYSIS AND DESIGN TECHNIQUES

Includes interactive techniques, computerized technology design and development programs, dynamic analysis techniques, environmental modeling, thermal modeling, and math modeling.

A88-34469
AN INTEGRATED COMPUTER AIDED ENGINEERING SYSTEM FOR SPACE STATION DESIGN
R. A. WHALE (SDRC Engineering Services, Ltd., Hitchin, England), M. BAKER, H. D. CHIGER, J. A. HABERMEYER, P. J. HIPOL

(SDRC, Inc., San Diego, CA) et al. IN: Computer applications in spacecraft design and operation. Berlin and New York, Springer-Verlag, 1987, p. 53-76.

A computer-aided engineering tool currently in use at NASA for system engineering and integration analysis of the space station is described. The tool combines spacecraft-specific analysis software called IDEAS (truss synthesizer, rigid body controls, plume impingement, orbital lifetime, orbit heat loads, and life support systems with general purpose interactive graphics, geometric database, solid modeller, and structural and thermal software to obtain an integrated package suitable for space station design. The capabilities and examples of the use of IDEAS are presented. V.L.

A88-37278#

METHODS FOR SPACECRAFT SIMULATION IN VIBRO-ACOUSTIC ENVIRONMENTS

P. G. BREMNER and D. C. RENNISON (Vipac Pty., Ltd., Australia) IN: National Space Engineering Symposium, 3rd, Canberra, Australia, June 30-July 2, 1987, Preprints of Papers. Barton, Australia/Brookfield, VT, Institution of Engineers/Brookfield Publishing Co., 1987, p. 232-237. refs

Seemingly quite different modelling approaches to spacecraft design are emerging for acoustic and random vibration environments. The authors endeavor to unify these methods as a single vibro-acoustics field. A good understanding of the theory is necessary to make decisions on cost-effective spacecraft analysis and test strategies. The paper describes three modelling strategies, their inter-relationships and their relative merits or realm of suitability. These are Finite Element Methods, Statistical Energy Analysis and the Power Flow Method. Original work by the authors is presented to demonstrate the application to aerospace structural design problems. Particular attention is drawn to the accuracy and useable frequency range of the different methods, including validation exercises using test data. Test facilities are proposed for the cost-effective simulation of vibro-acoustic environments in a manner appropriate to Australian needs. Author

A88-39500

SPACE PHOENIX

RANDOLPH H. WARE, THOMAS F. ROGERS, DAVID J. PADUA (External Tanks Corp., DE), and WALTER ORR ROBERTS (University Corporation for Atmospheric Research, Boulder, CO) Space Policy (ISSN 0265-9646), vol. 4, May 1988, p. 143-150. refs

The Space Phoenix Program to develop the Space Shuttle fleet's expended external fuel tanks for scientific and commercial use is discussed. The program is run through cooperation between the federal government and three private organizations, the University Corporation for Atmospheric Research (UCAR), the UCAR Foundation, and the External Tanks Corporation (ETCO). The 27.6 ft X 153 ft external tanks (ETs), which are jettisoned from the Shuttle to eliminate potentially harmful impact, are made of high-grade aluminum and are used to carry 70,000 cu ft of separate, pressurized hydrogen and oxygen. The Space Phoenix Program is studying the commercial and non-profit use of ETs in space for purposes such as manufacturing, research, and storage. One of its major objectives is to try to save ETs and park them in a high-altitude orbit to safeguard their potential value. The program is exploring the possible use of ETs to fulfill the need for space facilities and laboratories, and working to obtain the rights from the government to use, modify, and operate ETs. R.B.

A88-40524

SIMULATION - ANTIDOTE TO RISK

LEE DAY and GRAHAM SPEED (Singer Link-Miles, Ltd., Lancing, England) Spaceflight (ISSN 0038-6340), vol. 30, June 1988, p. 240-243.

The use of simulators to reduce risk in space programs is discussed. Simulation is used in system verification during the early phases of a project to substitute for missing system elements, allowing for verification of the overall system design, so that modifications can be made before hardware is manufactured. The new focus in developing simulators is on training analysis to provide a system tailored to the tasks and characteristics of trainees. This involves a structured progression incorporating only those stages of training found necessary through analysis. A number of simulators are networked in the final stage of training the flight crew, ground controllers, and the mission-related payload user and control personnel. In the development of the Columbus Attached Pressurized Module or the Japanese Experimental Module, software models and hardware mock-ups are linked together so that progressively larger simulations of the system can be performed. Prototype equipment is substituted for the models until the entire system is in place. The need for simulation continues after a mission launch because of the remoteness of support activity from the home base. R.B.

A88-40556

DESIGN OF A SOLAR POWER SATELLITE FOR CONSTRUCTION FROM LUNAR MATERIALS

GREGG E. MARYNIAK (Space Studies Institute, Princeton, NJ) and BRIAN TILLOTSON (Space Research Associates, Redmond, WA) Space Power (ISSN 0951-5089), vol. 7, no. 1, 1988, p. 27-36. refs

Solar power satellites may be constructed from materials mined on the moon and transported into free space by means of an electromagnetic catapult called a mass-driver. Both the mass-driver and the chemical processing techniques required to obtain construction materials from lunar soil have been demonstrated in the laboratory. A solar power satellite has been designed for construction from lunar materials. This design requires only 1 percent of its mass from the earth. Author

A88-42911#

OMV MULTIPLE DEPLOYMENTS OF LIGHTSATS

WILLIAM L. SMITH and JAMES D. WALKER (TRW, Inc., Federal Systems Div., Redondo Beach, CA) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 7 p. (AIAA PAPER 88-3518)

The design and capabilities of the NASA Orbital Maneuvering Vehicle (OMV) are reviewed, and the potential value of the Shuttle-borne OMV for deploying lightweight satellites (lightsats) into different orbits is discussed and illustrated with extensive drawings and diagrams. Assuming 100-lb lightsats in extended GAS canisters, the OMV could separate from the Orbiter at 16 nmi and deploy six lightsats each at altitudes 430, 700, and 970 nmi before rejoining the Orbiter at 160 nmi. Also considered are configurations with 8 or 12 200-lb lightsats and the fittings for Titan-4 launch of OMV/lightsat packages. T.K.

A88-43969#

A CONCEPT FOR MANNED VARIABLE GRAVITY FACILITIES

J. ALEX GIMARC IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 175-187. refs

This paper will discuss the needs for and the configurations of an early space platform that will provide artificial gravity. The platform will be a tethered dumbbell capable of rotation to provide artificial gravity levels up to 1-G earth normal with reasonable rotation rates. The facility should be able to provide life support and living quarters for a number of inhabitants, and should allow the study of the long term effects of various 'G' levels on the human body, plants and animals. It also may be able to minimize those problems by providing a 1-G habitat or crewmembers who might 'commute' to and from the workplace. This type of facility should be affordable, manned and operational in a minimum number of flights. It should also be capable of expansion to provide living quarters for those involved in large scale space manufacturing and construction projects. Author

A88-44898

BALLISTIC DESIGN OF SPACE SYSTEMS [BALLISTICHESKOE PROEKTIROVANIE KOSMICHESKIKH SISTEM]

PAVEL ROMANOVICH POPOVICH and BORIS SERGEEVICH SKREBUSHEVSKII Moscow, Izdatel'stvo Mashinostroenie, 1987, 240 p. In Russian. refs

The general principles of the ballistic design of space systems are examined. It is shown that the ballistic characteristics of various types of spacecraft are largely determined by the combination of tasks to be performed, technical constraints, and physical environment of the particular space mission. The stages of the process of orbital parameter selection are examined, and methods are presented for solving problems of the synthesis of dynamically stable space systems. V.L.

A88-46414

AN INTEGRATED APPROACH TO THE MINIMUM WEIGHT AND OPTIMUM CONTROL DESIGN OF SPACE STRUCTURES

N. S. KHOT (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 355-363. refs

Two procedures for the simultaneous optimization of a structural design for both minimum weight and active vibration control are characterized analytically in a brief review. The equations of motion for a typical system are derived, and the formulations of methods based on (1) minimum-weight design with constraints on the closed-loop eigenvalues and (2) minimum-weight design with constraints on the control gain norm are outlined. Numerical results for sample problems analyzed using the active-control algorithm ACOSS-FOUR (Strunce et al., 1980) are presented in tables. T.K.

A88-46516

TASKS OF THE SIMULATION INSTALLATIONS FOR SPACE FLIGHT OPERATIONS IN THE OPERATIONS CENTER FOR MANNED SPACE LABORATORIES [AUFGABEN DER SIMULATIONSANLAGEN FUER DEN RAUMFLUGBETRIEB IM BETRIEBSZENTRUM FUER BEMANNTE WELTRAUMLABORS]

KONRAD REINEL, GERHARD HEIMBOLD, THOMAS LANGE, and BERND SCHAEFER (DFVLR, Oberpfaffenhofen, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), June 1988, p. 5-10. In German.

Test installations being built for orbital applications in the DFVLR operational center for manned space operations are described. The activities, equipment, and personnel of the installations for rendezvous and docking, for servicing, and for large space structures are addressed. The building in which these installations are housed is briefly discussed. C.D.

A88-46968

INTERACTIVE RADAR ENVIRONMENT SIMULATION MODEL (IRESM)

ROBERT J. HANCOCK, PAUL ANTONIK, FRANCIS G. SHERRILL, JEFFREY A. MCKAY (Simulation Technology, Inc., Greenville, TX), and JOHN C. CLEARY (USAF, Rome Air Development Center, Griffiss AFB, NY) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 272-274.

A radar simulation computer program to evaluate various radar system designs and a comprehensive program to evaluate various large aperture antenna designs have been integrated into the Interactive Radar Environment Simulation Model (IRESM). This simulation has been used to evaluate a number of different surface-based radar systems. The IRESM and its components are examined. A detailed signal simulation is presented, which models radar signals as they are generated, propagated through the environment, reflected by scatterers, and processed. A program for the evaluation of electronically-scanned phased array antennas is discussed, which enables the user to perform quick and accurate analyses on a variety of antenna designs. R.B.

A88-46982

SIMULATION OF SPACE MANIPULATOR OPERATIONS (EUROSIM)

C. N. A. PRONK (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands), A. ELFVING (ESA, Noordwijk, Netherlands), E. ERSUE (ISRA Systemtechnik GmbH, Darmstadt, Federal Republic of Germany), and A. L. LIPPAY (CAE Electronics, Ltd., Montreal, Canada) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 845-850. refs
(Contract ESA-6482/85)

The requirements for the simulation software of a European robotics operations simulator (Eurosim) are outlined and discussed. Eurosim has to cover a wide range of applications including general research and development; design; development; testing, verification, and qualification; training of human operators; and operations planning support. In an early stage of definition of Eurosim, four main functional subsystems were identified: the simulation subsystem, the image generation subsystem, the real-word operations subsystem, and the supervision subsystem. It is suggested that standards in software development be used, such as modularity, calling standards, and high-level languages to minimize maintenance costs. K.K.

A88-46986

ORBITER SERVICER RENDEZVOUS SIMULATION (ORSIM)

AMIEL AMATO and MICKIE D. HOFFMAN (Advanced Technology, Inc., Reston, VA) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 964-969. SDIO-sponsored research.

Orbiter Servicer Rendezvous Simulation (ORSIM) is an automated tool that simulates sequential transfer maneuvers of an orbital maneuvering vehicle (OMV) transporting orbital replaceable units from a space-based depot, or logistics platform, to higher altitude SDI sdatellites. ORSIM calculates OMV energy expenditures (velocity changes) and event histories for various combinations of user-selected orbital transfer maneuvers. Additionally, ORSIM determines the optimal configuration/quantities of logistics platforms and OMVs which conform to the dynamics of differential nodal precession, given user-prescribed values of the scheduled maintenance cycle and required servicing times. ORSIM is coded in FORTRAN-77 and is resident on an IBM PC/AT. Author

A88-46987

SDI EXPERIMENT REQUIREMENTS LEAD TO NEW EMPHASIS ON SHUTTLE SIMULATION CAPABILITIES

B. L. HUFFMAN (Teledyne Brown Engineering, Huntsville, AL) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 976-978.

On-orbit simulation capabilities at Teledyne Brown's Space Programs Division are described and summarized. The background and history of developments are given along with an explanation of how SDI-related experiments have given new impetus to on-orbit shuttle simulation capabilities. Future enhancements planned for the on-orbit simulation are given which describe how it may be used for current and future projects. Author

A88-50836

EXPONENT DIAGRAM ANALYSIS OF FEEDBACK CONTROL SYSTEMS INCLUDING FLEXIBLE STRUCTURES

HUBERT HAHN IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 785-798.

Techniques for the analysis and design of feedback controllers for hydraulic or pneumatic test facilities (for applications such as earthquake, vehicle, and spacecraft testing) are developed and demonstrated. The method is designed to incorporate the effects of structural flexibility and provide better insight into the physics of system behavior; it comprises three main steps: symbolic computation of a characteristic polynomial, exponent-diagram analysis of the symbolic characteristic equation, and higher-order root-locus computation. These steps are described in detail and illustrated with extensive diagrams, graphs, and tables of numerical data for two sample problems. T.K.

A88-51386*# Sterling Software, Palo Alto, CA.
OPTIMUM CONFIGURATION OF HIGH-LIFT AEROMANEUVERING ORBITAL TRANSFER VEHICLES IN VISCOUS FLOW
CAROL B. DAVIES (Sterling Software, Palo Alto, CA) and CHUL PARK (NASA, Ames Research Center, Moffett Field, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, May-June 1988, p. 193-201. Previously cited in issue 17, p. 2472, Accession no. A85-37673. refs

A88-52334
WELDING THE SPACE STATION COMMON MODULE PROTOTYPE
T. J. BOSWORTH, C. M. MILLER, and C. C. GRIFFEE (Boeing Aerospace Co., Seattle, WA) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-34 to 5-41. refs

The construction of a prototype of the Space Station common module is examined. The prototype is 13.67 feet in diameter and 43.6 feet in length and consists of five basic components: skins, ring frames, gore sections, docking port, and window frame. The design and materials of construction for these components are designed. The variable polarity plasma arc welding process which was used in constructing the prototype is described. The weld requirements and the assembly sequence for building the prototype are considered. R.B.

A88-53226* Lockheed Missiles and Space Co., Palo Alto, CA
DESIGN AND TEST OF A MODIFIED PASSIVE ORBITAL DISCONNECT STRUT (PODS-IV)
IRAN E. SPRADLEY and RICHARD T. PARMLEY (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) IN: Advances in cryogenic engineering. Volume 33 - Proceedings of the Cryogenic Engineering Conference, Saint Charles, IL, June 14-18, 1987. New York, Plenum Press, 1988, p. 935-942. Research supported by Lockheed Missiles and Space Co., Inc. refs
(Contract NAS2-11946)

The design and testing of a modification to the Passive Orbital Disconnect Struts (PODS) III system (designed to reduce support conductance and superfluid-helium-tank dewar weights), PODS IV, are discussed. The PODS IV design was found to achieve a nominal increase of 630-812 percent in side-load resistance over the PODS-III design, with a predicted 15-percent increase in thermal conductance. It is noted that the increase in side-load resistance largely removes the limitation on length of the orbit tube inherent in the PODS III design. The higher resistance of the longer orbit tube results in lower total conductance for the PODS-IV design. R.R.

A88-53664#
SPACE OPERATIONS AND SPACE STATION REAL-TIME SIMULATION
D. HERNANDEZ, A. A. MOLINEROS, and W. C. WAGNER (Rockwell International Corp., Space Transportation Systems Div., Downey, CA) IN: AIAA, Flight Simulation Technologies Conference, Atlanta, GA, Sept. 7-9, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 304-312. refs
(AIAA PAPER 88-4627)

This paper describes the Space Operations and Space Station Simulator, a man-in-the-loop, real-time test bed designed to support the analysis, design, and evaluation of future space systems. The state-of-the-art, distributed, hybrid simulator was developed and built by the Space Tranportation Systems Division of Rockwell International. A high-fidelity facility with prototype Space Shuttle on-board computers and realistic Shuttle and Space Station controls and displays, the simulator is capable of real-time hardware- and human-in-the-loop simulation using embeddded and nonhomogeneous processors, cockpit controls and displays, and out-the-window graphic displays. Presented is an overview of the simulation configuration and capabilities, the hybrid computers and mathematical models, and the hardware and software implementation features. Author

A88-54896#
DESIGN AND DEVELOPMENT OF A COMPUTER CONTROLLED SYSTEM FOR SPACECRAFT STATIC TESTING
M. K. PADMANABHAN, M. V. KANNAN, and S. SHANKAR NARAYAN (ISRO, Structures Div., Bangalore, India) IN: Developments in Mechanics. Volume 14(a) - Midwestern Mechanics Conference, 20th, West Lafayette, IN, Aug. 31-Sept. 2, 1987, Proceedings. West Lafayette, IN, Purdue University, 1987, p. 245-250.

A typical configuration and detailed outline of the hardware/software developed for a computer controlled system for the static testing of large spacecraft structures are presented. Software features include gauge installation and checkout, access to on-line strain monitoring during loading and unloading, strain and stress analyses, and various data recording and plotting capabilities. It is noted that the present system eliminates the time delays and errors in measurement and analysis that are normally found in manual/semiautomatic loading setups. The system is shown to be versatile for data acquisition, analysis, and documentation. R.R.

N88-29332# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.). Space Div.
STUDY OF THE OPTIMIZATION OF SATELLITE SYSTEM DESIGN FOR TRANSFER ORBIT Final Report
BAETZ, K. FETZER, W. FINK, H. HUFNAGEL, H. KELLERMEIER, KLEINAU, W. MUELLER, and H. CHALMERS (Erno Raumfahrttechnik G.m.b.H., Bremen, West Germany) Paris, France ESA Apr. 1983 349 p
(Contract ESTEC-4908/81-NL-PP(SC))
(MBB-URV-135; ESA-CR(P)-2518; ETN-88-91960) Avail: NTIS HC A15/MF A01

Geostationary transfer orbit (GTC) characteristics of former geosynchronous satellites; satellite configurations as to GTO requirements; telemetry and telecommand, thermal, power, and attitude control subsystems as to stabilization modes and GTO constraints; and apogee injection strategies (single/multiple burn, steering law) were reviewed. The investigations were confined to 2 Ariane 4 payload classes (2500 kg in GTO, dual-launch and 4200 kg in GTO, single launch), three-axis or slow barbecue stabilization during transfer orbit, and use of a liquid apogee injection system with low thrust level (400 N). A recommendation for an overall system optimization is presented. ESA

N88-24172*# General Electric Co., Philadelphia, PA. Astro Space Div.
THE MULTI-DISCIPLINARY DESIGN STUDY: A LIFE CYCLE COST ALGORITHM Final Contractor Report
R. R. HARDING and F. J. PICHI Washington NASA Jun. 1988 30 p
(Contract NAS1-18032)
(NASA-CR-4156; NAS 1.26:4156) Avail: NTIS HC A03/MF A01 CSCL 09B

The approach and results of a Life Cycle Cost (LCC) analysis of the Space Station Solar Dynamic Power Subsystem (SDPS) including gimbal pointing and power output performance are documented. The Multi-Discipline Design Tool (MDDT) computer program developed during the 1986 study has been modified to include the design, performance, and cost algorithms for the SDPS as described. As with the Space Station structural and control subsystems, the LCC of the SDPS can be computed within the MDDT program as a function of the engineering design variables. Two simple examples of MDDT's capability to evaluate cost sensitivity and design based on LCC are included. MDDT was designed to accept NASA's IMAT computer program data as input so that IMAT's detailed structural and controls design capability can be assessed with expected system LCC as computed by MDDT. No changes to IMAT were required. Detailed knowledge of IMAT is not required to perform the LCC analyses as the interface with IMAT is noninteractive. Author

N88-24189*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MTK: AN AI TOOL FOR MODEL-BASED REASONING
WILLIAM K. ERICKSON and MARY R. RUDOKAS *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 1-5 Jun. 1988
Avail: NTIS HC A04/MF A01 CSCL 09B

A 1988 goal for the Systems Autonomy Demonstration Project Office of the NASA Ames Research Office is to apply model-based representation and reasoning techniques in a knowledge-based system that will provide monitoring, fault diagnosis, control, and trend analysis of the Space Station Thermal Control System (TCS). A number of issues raised during the development of the first prototype system inspired the design and construction of a model-based reasoning tool called MTK, which was used in the building of the second prototype. These issues are outlined here with examples from the thermal system to highlight the motivating factors behind them, followed by an overview of the capabilities of MTK, which was developed to address these issues in a generic fashion. Author

N88-24190*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INTEGRATION OF SYMBOLIC AND ALGORITHMIC HARDWARE AND SOFTWARE FOR THE AUTOMATION OF SPACE STATION SUBSYSTEMS
HUGH GREGG, KATHLEEN HEALEY, EDMUND HACK (Lockheed Engineering and Management Services Co., Inc., Houston, Tex.), and CARLA WONG *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 7-14 Jun. 1988 Previously announced as N88-15497
(Contract W-7405-ENG-48)
Avail: NTIS HC A04/MF A01 CSCL 09B

Expert systems that require access to data bases, complex simulations and real time instrumentation have both symbolic and algorithmic needs. Both of these needs could be met using a general purpose workstation running both symbolic and algorithmic codes, or separate, specialized computers networked together. The later approach was chosen to implement TEXSYS, the thermal expert system, developed by the NASA Ames Research Center in conjunction with the Johnson Space Center to demonstrate the ability of an expert system to autonomously monitor the thermal control system of the space station. TEXSYS has been implemented on a Symbolics workstation, and will be linked to a microVAX computer that will control a thermal test bed. The integration options and several possible solutions are presented. Author

N88-24332# Texas A&M Univ., College Station. Dept. of Nuclear Engineering.
A THERMAL EQUILIBRIUM MODEL FOR MULTI-MEGAWATT SPACE PLATFORMS
MARK DAVID DEHART *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 335-338 1987 Sponsored by DOE, Washington, D.C.
Avail: NTIS HC A22/MF A01

Due to the current research under the SDI and the SP-100 Project, much work is being done to determine the optimum design for a space based nuclear powered platform. The problem of thermal equilibrium temperature distributions which would be experienced on a multimegawatt platform using a nuclear reactor driven thermodynamic cycle for production of several megawatts of electrical power over extended periods of time, the temperatures to which electronics packages on the platform would be subjected, and what measures needed to ensure that such electronics could survive is addressed. Anticipated electronics used on such a platform may be able to withstand steady state temperatures of up to 600 K, while current high temperature electronics are limited to 475 K. Therefore, an effort is made to determine the conditions and requirements to be imposed on a platform that would result in temperatures at critical locations between 475 and 600 K. A numerical model was developed to estimate outer surface temperatures and radioisotopes based on radiation heat transfer. In this model, the effects of space, Earth, and Sun are represented by an averaged sink temperature of 250 K. Author

N88-25371*# Taylor and Associates, Inc., Wrightwood, CA.
SPACE STATION ARCHITECTURAL ELEMENTS AND ISSUES DEFINITION STUDY
T. C. TAYLOR, J. S. SPENCER, and C. J. ROCHA May 1986 78 p
(Contract NASA ORDER A-16516-C)
(NASA-CR-3941; NAS 1.26:3941) Avail: NTIS HC A05/MF A01 CSCL 22B

A study was conducted to define the architectural elements and issues of the Space Station. The objective of the study was to identify those questions which require further research and suggest ways in which the research can be undertaken. The study examined five primary topics, asked salient questions and described the merits of alternative solutions. Author

N88-29411*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
AN EXPERT SYSTEM FOR A DISTRIBUTED REAL-TIME TRAINER
STEVEN C. PURINTON and CAROLINE K. WANG *In its* Second Conference on Artificial Intelligence for Space Applications p 545-554 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 14B

The problem addressed by this expert system concerns the expansion of capability of a Real Time Trainer for the Spacelab flight crew. As requirements for more models or fidelity are placed upon the system, expansion is necessary. The simulator can be expanded using a larger processor or by going to a distributed system and expand by adding additional processors. The distributed system is preferable because it is more economical and can be expanded in a more incremental manner. An expert system was developed to evaluate modeling and timing capability within a real time training simulator. The expert system is based upon a distributed configuration. Components of the modeled system are control tasks, network tasks, emulator tasks, processors, displays, and a network. The distributed module expert system (DMES) allows the configuring of processors, tasks, display use, keyboard use, and selection of alternate methods to update the data buffer. Modules can be defined with execution occurring in a specific processor on a network. The system consists of a knowledge front end editor to interactively generate or update the knowledge base, an inference engine, a display module, and a recording module. Author

N88-29852# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).
PROCEDURES FOR UPDATING DYNAMIC MATHEMATICAL MODELS, TEST PHASE Final Report
B. CAESAR, E. ERBEN, H. HUENERS, M. LINK, J. MORENO-BARRAGAN, A. SCHUMANN-LUCK, F. VOGEL, and M. WEILAND (Kassel Univ., West Germany) Paris, France ESA Jun. 1987 413 p
(Contract ESTEC-6262/85-NL-PH)
(MEBS-38/87; ESA-CR(P)-2606; ETN-88-93036) Avail: NTIS HC A18/MF A01

Procedures for updating and identification of dynamic mathematical models were applied to real hardware problems. Small size (spring-mass, beam) structures, a medium size test structure, a spacecraft antenna module, and a whole spacecraft (MAROTS) were investigated. The small and medium size structures were manufactured, and tested with different test methods to get the modal parameters. The test data of the antenna module and the spacecraft were obtained from the relevant projects. The application of modal parameter identification with procedures working in the time domain and in the frequency domain

(ISSPA) and the correlation of results from different tests indicates the quality of test results in general. The general applicability of ISSPA is demonstrated. A highly formulized update procedure was applied to improve the mathematical models of the tested structures on the basis of modal test data. The advantages and drawbacks of such a method are described. The applicability to standard size spacecraft problems is demonstrated. ESA

N88-30350*# George Mason Univ., Fairfax, VA. Dept. of Computer Science.
PARALLEL AND DISTRIBUTED COMPUTATION FOR FAULT-TOLERANT OBJECT RECOGNITION
HARRY WECHSLER *In* NASA, Goddard Space Flight Center, The 1988 Goddard Conference on Space Applications of Artificial Intelligence p 275-293 Aug. 1988
Avail: NTIS HC A19/MF A01 CSCL 09B

The distributed associative memory (DAM) model is suggested for distributed and fault-tolerant computation as it relates to object recognition tasks. The fault-tolerance is with respect to geometrical distortions (scale and rotation), noisy inputs, occulsion/overlap, and memory faults. An experimental system was developed for fault-tolerant structure recognition which shows the feasibility of such an approach. The approach is futher extended to the problem of multisensory data integration and applied successfully to the recognition of colored polyhedral objects. Author

03

STRUCTURAL CONCEPTS

Includes erectable structures (joints, struts, and columns), deployable platforms and booms, solar sail, deployable reflectors, space fabrication techniques, and protrusion processing.

A88-35940#
SPACE STATION ERECTABLE TRUSS JOINT EVALUATION
J. H. PEEBLES and K. B. KEMPSTER (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 9 p.
(AIAA PAPER 88-2448)

The structural and functional suitability of five different joint concepts developed and fabricated as part of an advanced development project for the Space Station program is evaluated. The joints were tested in axial tension and compression to determine their inherent stiffness, damping, and nonlinear characteristics which may have a strong influence on the dynamic behavior of a Space Station or other large space structures such as those proposed for SDI concepts. Ease of operation, maintainability, and reliability of the joint concepts are also addressed. Underwater test results for two of the joints are also described. C.D.

A88-35941#
PERFORMANCE ENHANCEMENT OF PASSIVELY DAMPED JOINTS FOR SPACE STRUCTURES
JACKY C. PRUCZ and C. C. SPYRAKOS (West Virginia University, Morgantown) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 23 p. refs
(AIAA PAPER 88-2450)

This paper presents a theoretical performance analysis of different configurations for passively damped joints that could be used as alternatives to the conventional double-lap configuration. A rational approach is described for predicting the effects of structural interactions between various constituents of a passively damped joint on some of its performance characteristics, including weight, damping, strength, and stiffness in the load transfer direction. Numerical results are described for a rhomblike geometry where the viscoelastic adhesive is enclosed by the elastic joint measurements, and for the application of lateral pressure-tension to the outer adherends of a double-lap joint. A rational methodology for developing innovative joining concepts for space structure is described which can provide enhanced dissipation of vibrational energy without serious penalties in strength, stiffness, or weight characteristics. C.D.

A88-35944#
SPACE STATION TRUSS STRUT TUBE DESIGN
KARL B. KEMPSTER and HANK W. BABEL (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 6 p.
(AIAA PAPER 88-2471)

The paper describes the rationale that led to the current Space Station truss strut tube design. The system-level and derived requirements and the design options developed to satisfy them are discussed. The designs addressed both material and construction options. The selection criteria for evaluating the design options are reviewed and the recommended truss strut tube design is described. Author

A88-38689*# PRC Kentron, Inc., Hampton, VA.
SENSITIVITY ANALYSIS OF A DEPLOYABLE THREE LONGERON TRUSS BEAM DESIGNED FOR MINIMUM MEMBER LOADS DURING DEPLOYMENT
DIRK B. WARNAAR (PRC Kentron, Inc., Hampton, VA) and JERROLD M. HOUSNER (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988. 9 p. refs
(AIAA PAPER 88-2436)

The significant design variables of a deployable three longeron truss beam, designed for minimum member loads during deployment, are identified and the sensitivity of the load level in the members of the truss beam due to variations of the design variables is established. The analysis of the deployment models, developed in this paper, is carried out using a commercially available computer code, called DADS. Based on the results of the analysis, guidelines are formulated for the design of a deployable three longeron truss beam to achieve minimum loads in the members during deployment. The paper concludes with a brief discussion of the applicability of the approach, taken in this paper, to other truss configurations. Author

A88-41038
A CONTINUUM MODEL FOR THE NONLINEAR ANALYSIS OF BEAM-LIKE LATTICE STRUCTURES
D. B. MCCALLEN (Lawrence Livermore National Laboratory, Livermore, CA) and K. M. ROMSTAD (California, University, Davis) Computers and Structures (ISSN 0045-7949), vol. 29, no. 2, 1988, p. 177-179, 181-197. refs

A simple equivalent continuum model has been developed for the geometrically nonlinear analysis of beam-like lattice structures. Two important features of the model are the simplicity of the calculation of the continuum properties and the ability of the continuum to accurately predict the behavior of rigid-joint as well as pin-joint lattices. The equivalence of the continuum and lattice is established by requiring the strain energy of the continuum to equal the strain energy of the lattice for a finite set of assumed deformation modes. It is shown that an additional strain energy term not found in classical Timoshenko beam theory must be included in the continuum strain energy function in order to accurately approximate the behavior of rigid-joint frames. A finite element discretization is applied to the continuum to obtain numerical solutions for the continuum model. By comparison with discrete finite element results for the lattice, the accuracy of the continuum methodology is demonstrated for both static and dynamical problems. For the nonlinear problems studied, the continuum solutions were found to require only a small fraction of the CPU time needed for the discrete finite element solutions. Author

A88-44839#

A SELF-CONSISTENT TENSION SHELL STRUCTURE FOR APPLICATION TO AEROBRAKING VEHICLE AND ITS AERODYNAMIC CHARACTERISTICS

TAKASHI ABE (Institute of Space and Astronautical Science, Sagamihara, Japan) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p. refs

(AIAA PAPER 88-3405)

A new method determining a tension shell structure for an application to an aerobraking vehicle is proposed. In this method, the tension shell configuration can be determined self-consistently in that the pressure distribution which is used to determine the shell configuration can be consistent with the one appearing on the configuration. The aerodynamic characteristics of the tension shell is also investigated numerically. Author

A88-45452#

THE HIPPARCOS SOLAR PANELS [DE ZONNEPANELEN VAN HIPPARCOS]

T. KONINK (Fokker Space and Systems, Amsterdam, Netherlands) Ruimtevaart, vol. 37, April 1988, p. 12-14. In Dutch.

The design and test performance of the solar panels for the ESA Hipparcos astrometric satellite are reviewed. The panels are of the type used on MARECS and ECS: 2240 180-micron-thick back-surface-reflecting solar cells are mounted on each 1.69 x 1.29 x 0.023-m Al-honeycomb/CFRP panel, electrically insulated with a 50-micron layer of kapton, and shielded from micrometeorites by a 150-micron protective layer. Three panels are attached with hinges to three of the six side faces of the Hipparcos spacecraft and unfolded after it attains GEO. The cells operate at a fixed voltage of 53 V and produce total power of about 450 W. The panels have passed qualification tests including temperature changes between -170 and +85 C, mechanical loads of 45 g, and impact tests of the hinges, as well as vibration and acoustic tests as part of the Hipparcos flight model. T.K.

A88-47964#

TWO-DIMENSIONAL DEPLOYABLE TRUSS STRUCTURES FOR SPACE APPLICATIONS

JUNJIRO ONODA (Tokyo, University, Japan) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 109-116. refs

A variable-length diagonal (VLD) member-employing truss that can be folded by elongation of some members and a sliding-hinge, double-fold (SHDF) truss that can be folded upon sliding some of its hinge assemblies are presently compared to existing deployable truss alternatives. It is established that the number of mechanical elements which must be actuated and locked during VLD and SHDF deployment is only about half as many as the number involved in double-fold and biaxial double-fold types. The neccessary conditions for the trusses' folding/deployment are formulated, and the design flexibility of each concept in the formation of a globally curved surface is investigated. O.C.

A88-50891

BEAM MODIFICATIONS OF STRUCTURAL SYSTEMS UTILIZING THE RECEPTANCE APPROACH WITH STATIC FLEXIBILITY

R. R. LIN, A. B. PALAZZOLO, R. M. ALEXANDER, and C. H. GERHOLD (Texas A & M University, College Station) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1557-1564. refs

Structural modification algorithms were developed for reanalyzing a structure subjected to a local change. The goal is to predict the modified system modal parameters using only the experimental data from the original system. Most structural modification methods are based on the eigensolution derivative concept. In this research the modification algorithm consists of adding a beam element to the structure and then predicting not only the new natural frequencies, but also the damping ratios. Two different algorithms were examined: a damped receptance approach and an eigensolution derivative approach. The results of these two algorithms were compared to those from an ANSYS finite element model. In addition, the effects of including static flexibility in the receptance approach were examined. Experimental tests on a cantilever beam were conducted. The results of the receptance method were excellent, especially when the static deflections were utilized; however, the results of the eigensolution derivative approach were poor if the local modification was large. Author

A88-54722

A NUMERICAL METHOD FOR THE ANALYSIS OF COUPLING TO THIN WIRE STRUCTURES

ROGER A. DALKE (Electro Magnetic Applications, Inc., Lakewood, CO) IN: IEEE 1988 International Symposium on Electromagnetic Compatibility, Seattle, WA, Aug. 2-4, 1988, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 55-61. refs

(Contract DAAH01-85-D-A015)

A numerical method for determining the response of thin-wire structures to an arbitrary time-varying electromagnetic field is presented. Explicit central-difference techniques are utilized to calculate the vector potential and charge at discrete locations on the wire structure. The scalar potential is obtained by integrating the time-retarded charge distribution over the structure. The unknown current is obtained by solving the discrete equations relating the current and vector potential for each time step. The technique is used to determine the current distribution due to a plane wave incident on a large antenna composed of thin wires. Coupling calculations are in good agreement with well-established numerical methods. This approach is substantially different from existing time-domain integral-equation techniques and allows for easy implementation of wire connections, changes in wire diameter and computer-code optimization by eliminating unnecessary calculations. The technique can be coupled with 3-D finite-difference codes to cover structures that are attached to the wires. The methods described have been used successfully to calculate coupling to a log-periodic antenna. I.E.

N88-20347# National Aerospace Lab., Amsterdam (Netherlands). Space Div.

MOVEABLE THERMAL JOINTS FOR DEPLOYABLE OR STEERABLE SPACECRAFT RADIATOR SYSTEMS

A. A. M. DELIL 20 Feb. 1987 16 p Presented at the 17th Intersoc. Conf. on Environmental Systems' European Thermal Control Session, Seattle, Wash., Jul. 1987 Previously announced as A88-21118

(NLR-MP-87016-U; B8725241; ETN-88-91739; AD-B115513L)

Avail: NTIS HC A03/MF A01

Ways to handle the heat dissipated by the batteries of the Columbus Polar Platform are discussed. One solution is to equip each battery Orbital Replacement Unit with a dedicated heat pipe radiator. Such a radiator, being stowed during launch, has to be deployed in orbit and might be chosen to be steerable to achieve maximum radiator performance, hence minimum radiator size. The coupling between battery and deployable or steerable radiator has to incorporate a rotatable or flexible thermal joint. Drivers for the design of such joints optimize radiator size, and a small deployment/retraction torque or steering torque. Concepts for moveable thermal joints are described. Possible candidates for near-term application are: the flexible heat pipe; the braided conductor; the hydraulically or mechanically clamped joint; and the low melting point alloy filled, grease filled or (low pressure) gas filled (finned) heat exchanger. Concepts for non-near term applications include the radial heat pipe (condenser rotatable with respect to evaporator); the oscillating hydrodynamic joint (flexible or rotatable); the rollable membrane radiator; and the articulated or split heat pipe. ESA

N88-21195# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.).

SOME HIGHLIGHTS ON ROSAT MECHANISMS

P. PAWLOWSKI and H. HEIMERDINGER (Dornier-Werke G.m.b.H., Friedrichshafen, West Germany) *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 21-25 Dec. 1987
Avail: NTIS HC A14/MF A01

The ROSAT antenna boom mechanism (ABM), and telescope door mechanism (TDM) are described. The ABM is a 3.5 m long CFRP tube with 80 mm outer diameter and 4.5 mm wall thickness. It carries an S-band communication antenna at the tip, and a magnetometer for attitude measurements in the middle. It is stowed for launch and released by a kick spring, which causes a 180 deg rotation of the boom. Latching stubs bolted to the hinge bracket fix it in position. The TDM is used to avoid contamination of the gold coated X-ray mirrors before use. In orbit it is opened by a pyrotechnical device/kick spring, by a 90 deg rotation and acts as a sun shade. ESA

N88-21196# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
THE CTM PROGRAM OF MASTS AND THE CTM ENGINEERING MODEL
M. AGUIRRE, R. BUREO, F. DELCAMPO, and M. FUENTES (Sener S.A., Madrid, Spain) *In its* Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 27-35 Dec. 1987
Avail: NTIS HC A14/MF A01

A biconvex tube mast that can be flattened and then rolled up around a drum into a small volume package was developed. A drive system pulls the tube by the edges to deploy it. The mast can be manufactured in metal and composite; in both cases a continuous manufacturing method is used, to provide tubes of unlimited length. An engineering model with composite tubes was built and tested with satisfactory results. A qualification model with metal or composite tubes is proposed. Applications include satellite antenna and solar array deployment. ESA

N88-21197# I.A.M. Rinaldo Piaggio, Finale Ligure (Italy).
DEPLOYABLE/RETRIEVABLE BOOM: ONE APPLICATION TO TETHERED SATELLITE
P. BECCHI and D. MIRANDA *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 37-46 Dec. 1987
Avail: NTIS HC A14/MF A01

The development, design, and qualification of a telescopic tubular deployable/retrievable boom rated to shuttle requirements for the tethered satellite mission are reviewed. The mechanism includes jettisoning provision and deployable harness for the supported payloads connection. Applications to other payloads and comparisons with other designs are discussed. ESA

N88-21198# Max-Planck-Inst. fuer Physik und Astrophysik, Garching (Germany, F.R.). Inst. fuer Extraterrestrische.
DEPLOYABLE BOOMS AND ANTENNAS ON AMPTE-IRM
J. E. STOECKER and P. PARIGGER *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 47-50 Dec. 1987
Avail: NTIS HC A14/MF A01

Two instruments of the AMPTE ion release module satellite were deployed radially by rigid booms with two and one articulated sections respectively, which had to be balanced in the stowed and deployed configuration. Made from carbon and glass fiber, they deflected after deployment and protected the instruments against the locking shock. All boom mechanisms were made from nonmagnetic material. Tests were performed to qualify the booms. Two S-band radiators on top of 1.4 m solid booms were pivoted to the satellite skirt. Both could be oriented either parallel to the spin axis or, after deployment, perpendicular to it. A third S-band radiator was extended axially from the satellite aft end. The extension system was a modified commercial automobile antenna drive. The release mechanism of the 16 canisters which were ejected from the satellite to produce barium and lithium-plasma clouds is described. ESA

N88-21201# Fokker B.V., Amsterdam (Netherlands).
THE DEVELOPMENT STATUS OF THE STRONGBACK ARRAY
R. ZWANENBURG *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 65-71 Dec. 1987
Avail: NTIS HC A14/MF A01

A lifesize model of the strongback array (STAR) was built. The model demonstrates the feasibility of this deployable and retractable support structure. Deployment analyses show good correspondence with the test results. The measured bending stiffness of the mast in deployed condition is between 50,000 to 200,000 Nmsq. Stiffness depends on the preload condition and the considered load environment. Mast stiffness may decrease significantly if the mast shape deviates from the ideal deployed condition. A very simple mast layout without a bottom sliding rail is possible for deployments of experiment payloads. ESA

N88-21202# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
A SEQUENTIALLY DEPLOYABLE STRUCTURE FOR SPACE APPLICATIONS
F. PANIN, M. EIDEN, M. SIERRA, and J. RIVACOBA (Sener S.A., Las Arenas, Spain) *In its* Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 73-82 Dec. 1987
Avail: NTIS HC A14/MF A01

A large truss structure which deploys sequentially from the spacecraft was designed, and the deployment was simulated using the Automatic Dynamic Analysis of Mechanical Systems package. The development model of the deployable truss is formed by three bays. When in the deployed configuration, each bay is a cube of 1 m side formed of 2 battens connected by struts. By the use of joints in the middle and at the end of struts, the bay can be folded to a very reduced length. Actuation is achieved by torsional springs in the joints and the deployment is controlled according to a chosen law by the release of retaining cables. ESA

N88-21203# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Space and Strategic Systems Div.
AEROSPATIALE UNFURLABLE REFLECTOR AND ASSOCIATED MECHANISMS
Y. BROUSTET, G. BRAZZINI, and E. JOSEPH-GABRIEL *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 83-89 Dec. 1987
Avail: NTIS HC A14/MF A01

An unfurlable antenna concept, particularly the spring actuated hinge used in truss motorization, is presented. A 9 m reflector consisting of 24 prismatic truss sections with articulated connecting bars and a similar 4 m design are described. Torque characteristics of the hinge are discussed. ESA

N88-21204# Spar Aerospace Ltd., Weston (Ontario). Canadian Space Station Program.
SYSTEM AND CONCEPT DESIGN OF THE SSRMS LATCHING END EFFECTOR
E. QUITTNER, R. VANDERSLUIS, J. RAKHSHA, and I. FARMER *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 93-103 Dec. 1987
Avail: NTIS HC A14/MF A01

The latching end effector of the relocatable Space Station Remote Manipulator System (SSRMS) for the Mobile Servicing Center contribution to the Space Station is presented. The latching end effector, when installed on the two ends (shoulder and wrist) of the symmetrical manipulator arm provides the capability to interchange wrist and shoulder of the arm thus enabling manipulator relocatability. The latching end effector combines the snare and rigidize features of the existing Shuttle RMS end effector, with latching and umbilical electrical power and signal transfer features. Modified, existing, and new components are combined in an assembly of modular, orbit replaceable units. The existing components are enhanced by adding redundancy and orbit-maintainability provisions. Associated with the above is the power and data grapple fixture. The functions associated with the existing snare/rigidize and the new latching and umbilical elements can be executed independently. The SRMS based end effector and the SSRMS based functions can, therefore, be performed with the existing and the modified grapple fixtures as an interface. ESA

N88-21205# Sener S.A., Madrid (Spain).
LATCHING MECHANISMS FOR IOC
F. DELCAMPO *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 105-112 Dec. 1987
Avail: NTIS HC A14/MF A01

Two different latch mechanisms were designed for the IOC experiment in EURECA, to help the antenna pointing mechanism (APM) withstand the flight loads and to increase its first natural eigenfrequency. In both cases, the main objective is to obtain a high stiffness, paying special attention to the structural discontinuities (clamp, hinges, etc.), in order to eliminate the backlash. This is obtained mainly by preloading these discontinuities and by selecting adequate materials to avoid problems of differential CTE that could change the preload in critical areas. The first latching system consists of two overcenter latches driven by a stepper motor through a worm gear reducer. Each of them locks one of the two degrees of freedom of the APM during launch and reentry. The second system has three pyrotechnically released mechanisms which fix the APM during launch. ESA

N88-21211# Societe Nationale Industrielle Aerospatiale, Cannes (France).
THE SPOT SOLAR ARRAY. BOX OPENING MECHANISMS PHYSICAL VAPOR DEPOSITION (PVD)-MOS2: LUBRICATED SLIDES. FUNCTIONAL EVALUATION
J. F. PATIN, J. L. CECCONI, L. DECRAMER, and E. CONDE (Centre National d'Etudes Spatiales, Toulouse, France) *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 161-166 Dec. 1987
Avail: NTIS HC A14/MF A01

To estimate in-flight safety margins and to delineate the parameters which influence the friction coefficient, the MoS2 lubrication of the opening mechanism for the stowage box of the SPOT solar array, a set of steel slides restrained by aluminum alloy jumpers, was investigated. Effects of moisture, vacuum, and repeated operations on friction were studied. Measurements on the stowage box slides show low initial dispersions of the friction characteristics; mean reduction of friction effects by 60 percent to be considered for box opening in orbit with respect to the friction values measured in ground tests at 70 percent moisture; and 10 openings as the desirable number of prelaunch operations, with the frictional characteristics thus stabilized still preserved after 24 openings at least. ESA

N88-21212# RCA Aerospace and Defense, Princeton, NJ. Astro-Space Div.
DEVELOPMENT OF AN INTERMODULE CONNECTOR FOR SERVICEABLE SPACECRAFT
A. P. MATTHEWS, S. W. JACKSON, D. W. GROSS, and O. L. REGALADO *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 169-176 Dec. 1987
Avail: NTIS HC A14/MF A01

An Intermodular Connector (IMC) that can be applied universally to all types of spacecraft modules to optimize the remote mating of platform modules was developed. The operating principle is based on gross alignment to put the screw in contact with the floating nut. Once the face plates are together, the screw continues to rotate, drawing the connector plate down. The IMC uses an acme threaded screw mechanism for closure, rigidization, and connector-mating functions. This mechanism, centrally located on a triangular plate, was manufactured in three parts: the motor and gears, the acme threaded screw, and the floating nut. Mechanical models for proof of concept testing were built. ESA

N88-21217# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).
DESIGN OF A LINEAR ACTUATOR AND BREADBOARD TEST RESULT
R. G. HOSTENKAMP *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 207-210 Dec. 1987
Avail: NTIS HC A14/MF A01

For the set of 15 mechanisms required to control the end positions of the deployable antenna petals of the Far Infrared and Submillimeter Space Telescope, a linear actuator capable of generating submicron steps was designed. The microsteps of a stepper motor are transferred by a spindle to a lever which deflects a slotted circular spring. The resulting diametral change of the spring represents the output stroke of the actuator. By a thermally stable design utilizing conventional material, the actuator is suited for an operational temperature range from 80 C to cryogenic conditions. The design of the linear actuator is described and test results from a breadboard model are reported. ESA

N88-21225# Sener S.A., Madrid (Spain).
THE EURECA ANTENNA DEPLOYMENT AND RETRACTION MECHANISMS
M. FUENTES, C. PASCUAL, and R. BUREO *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 261-266 Dec. 1987
Avail: NTIS HC A14/MF A01

The design of the Antenna Deployment and Retraction Mechanisms (ADRM) and the qualification test are described. The ADRM consists of a 2 m CFRP boom which is hinged at the S/C mounting interface and latched against the S/C structure at the other end, where the S-band antenna is attached. The hinge is actuated by a dc motor with gear box incorporated, and an external worm gear. The latch that holds the ADRM boom for launch and reentry is an overcentered four bar latch, prestressed by a torsion bar, and opened and closed by a motor identical to the one used in the hinge. Status of ADRM operation phases is monitored by microswitches. ESA

N88-21226# British Aerospace Public Ltd. Co., Stevenage (England). Space and Communications Div.
QUALIFICATION OF THE OLYMPUS REACTION WHEEL
G. J. STURTIVANT *In* ESA, Proceedings of the 3rd European Space Mechanisms and Symposium p 267-272 Dec. 1987
Avail: NTIS HC A14/MF A01

Functional (torque) vibration, thermal vacuum, and life tests on the OLYMPUS satellite 10 Nms reaction wheel are summarized. Test equipment and procedures are described. Results are satisfactory. ESA

N88-21227# British Aerospace Public Ltd. Co., Stevenage (England). Space and Communications Div.
DEVELOPMENT AND QUALIFICATION OF THE OLYMPUS ANTENNA POINTING MECHANISM
P. J. LOVETT *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 273-280 Dec. 1987
Avail: NTIS HC A14/MF A01

The OLYMPUS antenna pointing mechanism (APM), a modular mechanical unit which interfaces between antenna reflectors and the spacecraft structure and which is capable of reorientating the reflectors with respect to the spacecraft, is presented. The APM can support reflectors in the launch phase and in the on-station mode. Reorientation of the reflectors is carried out in open loop mode where the APM is repointed upon command from the ground, and in closed loop mode where the APM is required to respond on a continuous basis to RF error signals. In both modes the APMs are controlled by the APM electronics (APME) which generates the required stepping demands for the APM. On OLYMPUS five such APM are controlled by one electronics unit, the APME. These equipments form the antenna pointing subsystem. Four of the mechanisms operate in open loop mode and the fifth can operate both in on and off boresight of a radio frequency

beacon. Test results and design modifications are summarized.
ESA

N88-21229# British Aerospace Public Ltd. Co., Stevenage (England). Space and Communications Div.
QUALIFICATION TESTING OF THE EUROSTAR SOLAR ARRAY DRIVE MECHANISM (SADM)
I. D. HENDERSON *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 285-294 Dec. 1987
Avail: NTIS HC A14/MF A01

The EUROSTAR satellite communication platform solar array drive power ring unit; baseplate shaft and main bearing assembly; motor and gearbox assembly; signal slip-ring unit; and datum sensors are described. Subassembly; nonoperational; functional; vibration; thermal vacuum; and accelerated life tests are summarized.
ESA

N88-21233# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
DOCKING/BERTHING SUBSYSTEM: DESIGN AND BREADBOARD TEST
N. CABLE and J. HARTMANN (Dornier-Werke G.m.b.H., Friedrichshafen, West Germany) *In its* Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 317-326 Dec. 1987
Avail: NTIS HC A14/MF A01

Based on a low impact docking concept and a latching mechanism concept, a docking/berthing subsystem and its operations were defined. A set of four breadboard models of the latch were manufactured and locking tests were performed on a four degree of freedom air bearing table. The tests demonstrate feasibility of the low impact docking concept under the test facility conditions.
ESA

N88-21237# Pacific Northwest Labs., Richland, WA.
FABRIC SPACE RADIATORS
Z. I. ANTONIAK, W. J. KROTIUK, B. J. WEBB, J. T. PRATER, and J. M. BATES Jan. 1988 79 p
(Contract DE-AC06-76RL-01830)
(DE88-005569; PNL-6458) Avail: NTIS HC A05/MF A01

Future Air Force space missions will require thermal radiators that both survive in the hostile space environment and stow away for minimal bulk during launch. Advances in all aspects of radiator design, construction, and analysis will be necessary to enable such future missions. Currently, the best means for obtaining high strength along with flexibility is through structures known as fabrics. The development of new materials and bonding techniques has extended the application range of fabrics into areas traditionally dominated by monolithic and/or metallic structures. Given that even current spacecraft heat rejection considerations tend to dominate spacecraft design and mass, the larger and more complex designs of the future face daunting challenges in thermal control. Ceramic fabrics bonded to ultra-thin metal liners (foils) have the potential of achieving radiator performance levels heretofore unattainable, and of readily matching the advances made in other branches of spacecraft design. The research effort documented here indicates that both pumped loops and heat pipes constructed in ceramic fabrics stand to benefit in multiple ways. Flexibility and low mass are the main advantages exhibited by fabric radiators over conventional metal ones. We feel that fabric radiators have intrinsic merits not possessed by any other radiator design and need to be researched further.
Author

N88-21469*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE 15-METER DIAMETER HOOP/COLUMN ANTENNA SURFACE CONTROL ACTUATOR SYSTEM
ELVIN L. AHL, JR. and JAMES B. MILLER *In its* The 22nd Aerospace Mechanisms Symposium, p 1-11 May 1988
Avail: NTIS HC A18/MF A01 CSCL 13E

The design, development, and implementation status of the Surface Control Actuator System (SCAS) for the Hoop/Column Antenna are described with the primary focus on the design of the mechanical element. The SCAS is an electromechanical system that will automatically adjust the antenna shape by changing the length of control cords. Achieving and maintaining the proper surface shape and smoothness are critical to optimizing the electromagnetic characteristics of the antenna.
Author

N88-21471*# Rexnord Aerospace Mechanisms, Torrance, CA.
STRUCTURAL LATCHES FOR MODULAR ASSEMBLY OF SPACECRAFT AND SPACE MECHANISMS
WILLIAM MCCOWN and NEAL BENNETT *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium p 29-44 May 1988
Avail: NTIS HC A18/MF A01 CSCL 13E

Latching techniques are changing from early approaches due to the advent of berthing technology. Latch selection for a given interface may be conducted by evaluating candidate capabilities which meet functional interface requirements. A judgment criteria system is presented along with an example of its use in choosing the Rollerscrew Structural Latch (RSL) for the NASA Flat Plate Interface Prototype (FPIP). Details are given on Rollerscrew operation, design, and development difficulties. A test plan is also outlined for the RSL and FPIP.
Author

N88-21472*# AEC-Able Engineering Co., Inc., Goleta, CA.
THERMALLY STABLE DEPLOYABLE STRUCTURE
COLLEEN M. KEGG *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium, p 45-57 May 1988
Avail: NTIS HC A18/MF A01 CSCL 20K

A deployable structure which meets stringent thermal and strength requirements in a space environment was developed. A mast with a very low coefficient of thermal expansion (CTE) was required to limit the movement from thermal distortion over the temperature range of -200 C to 80 C to .064 cm (.025 in). In addition, a high bending strength over the temperature range and weight less than 18.1 kg (40 lbs) was needed. To meet all of the requirements, a composite, near-zero CTE structure was developed. The measured average CTE over the temperature range for the mast was .70 x .000001/C (.38 x .000001/F). The design also has the advantage of being adjustable to attain other specific CTE if desired.
Author

N88-21473*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE X-BEAM AS A DEPLOYABLE BOOM FOR THE SPACE STATION
LOUIS R. ADAMS *In its* The 22nd Aerospace Mechanisms Symposium, p 59-66 May 1988
Avail: NTIS HC A18/MF A01 CSCL 22B

Extension of antennas and thrust modules from the primary structure of the space station will require deployable beams of high stiffness and strength, as well as low mass and package volume. A square boom cross section is desirable for interface reasons. These requirements and others are satisfied by the X-beam. The X-beam folds by simple geometry, using single-degree-of-freedom hinges at simple angles, with no strain during deployment. Strut members are of large diameter with unidirectional graphite fibers for maximum beam performance. Fittings are aluminum with phosphor bronze bushings so that compliance is low and joint lifetime is high. The several beam types required for different applications on the space station will use the same basic design, with changes in strut cross section where necessary. Deployment is by a BI-STEM which pushes the beam out; retraction is by cables which cause initial folding and pull the beam in.
Author

N88-21475*# Old Dominion Univ., Norfolk, VA.
ON THE DANGER OF REDUNDANCIES IN SOME AEROSPACE MECHANISMS
M. CHEW *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium, p 87-98 May 1988

(Contract NAS1-17993)
Avail: NTIS HC A18/MF A01 CSCL 13I

An attempt is made to show that redundancies in some aerospace mechanisms do not generally improve the odds for success. Some of these redundancies may even be the very cause for failure of the system. To illustrate this fallacy, two designs based on the Control of Flexible Structures I (COFS I) Mast deployer and retractor assembly (DRA) are presented together with novel designs to circumvent such design inadequacies, while improving system reliability. Author

N88-21478*# Toshiba Corp., Kawasaki (Japan). Mechanical Engineering Lab.
DEVELOPMENT OF A MAGNETICALLY SUSPENDED, TETRAHEDRON-SHAPED ANTENNA POINTING SYSTEM
KENICHI TAKAHARA, TAMANE OZAWA, HIROSHI TAKAHASHI, SHITTA SHINGU, TOSHIRO OHASHI, and HITOSHI SUGIURA *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium p 133-147 May 1988
Avail: NTIS HC A18/MF A01 CSCL 13I

A magnetically suspended, tetrahedron-shaped antenna pointing system is proposed for use in a multibeam broadcasting satellite system in the future. The structure of this system is presented, along with its design concept and the functional test results which were obtained in a laser tracking system in the laboratory. According to these results, it has been confirmed that the system has many advantages over conventional systems and excellent performance. Author

N88-21491*# McDonnell-Douglas Astronautics Co., Huntington Beach, CA.
SPACE STATION FULL-SCALE DOCKING/BERTHING MECHANISMS DEVELOPMENT
GENE C. BURNS, HAROLD A. PRICE, and DAVID B. BUCHANAN *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium p 325-340 May 1988
Avail: NTIS HC A18/MF A01 CSCL 22B

One of the most critical operational functions for the space station is the orbital docking between the station and the STS orbiter. The program to design, fabricate, and test docking/berthing mechanisms for the space station is described. The design reflects space station overall requirements and consists of two mating docking mechanism halves. One half is designed for use on the shuttle orbiter and incorporates capture and energy attenuation systems using computer controlled electromechanical actuators and/or attenuators. The mating half incorporates a flexible feature to allow two degrees of freedom at the module-to-module interface of the space station pressurized habitat volumes. The design concepts developed for the prototype units may be used for the first space station flight hardware. Author

N88-21493*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DEVELOPMENT OF A ROTARY FLUID TRANSFER COUPLING AND SUPPORT MECHANISM FOR SPACE STATION
O. H. BRADLEY, JR., J. A. COSTULIS, and A. H. PORTER (PRC Kentron, Inc., Hampton, Va.) *In its* The 22nd Aerospace Mechanisms Symposium p 355-371 May 1988
Avail: NTIS HC A18/MF A01 CSCL 13K

A design was developed for a rotary fluid coupling to transfer coolant fluids (primarily anhydrous ammonia) across rotating joints of the space station. Development testing using three conceptual designs yielded data which were used to establish the design of a multipass fluid coupling capable of handling three fluid circuits. In addition, a mechanism to support the fluid coupling and allow an astronaut to replace the coupling quickly and easily was designed. Author

N88-23827* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
LOCKING HINGE Patent
CLARENCE J. WESSELSKI, inventor (to NASA) 12 Apr. 1988 9 p Filed 29 Oct. 1986 Supersedes N87-18595 (25 - 11, p 1446)
(NASA-CASE-MSC-21056-1; US-PATENT-4,736,490; US-PATENT-APPL-SN-934397; US-PATENT-CLASS-16-292; US-PATENT-CLASS-16-297; US-PATENT-CLASS-16-326; US-PATENT-CLASS-16-332; US-PATENT-CLASS-16-345; US-PATENT-CLASS-16-347; US-PATENT-CLASS-16-349) Avail: US Patent and Trademark Office CSCL 22B

The space station configuration currently studied utilizes structures which require struts to be hinged in the middle in the stowed mode and locked into place in the deployed mode. Since there are hundreds of hinges involved, it is necessary that they have simple, positive locking features with a minimum of joint looseness or slack. This invention comprises two similar housings hinged together with a spring loaded locking member which assists in making as well as breaking the lock. This invention comprises a bracket hinge and bracket members with a spring biased and movable locking member. The locking or latch member has ear parts received in locking openings where wedging surfaces on the ear parts cooperate with complimentary surfaces on the bracket members for bringing the bracket members into a tight end-to-end alignment when the bracket members are in an extended position. When the locking member is moved to an unlocking position, pivoting of the hinge about a pivot pin automatically places the locking member to retain the locking member in an unlocked position. In pivoting the hinge from an extended position to a folded position, longitudinal spring members are placed under tension over annular rollers so that the spring tension in a folded position assists in return of the hinge from a folded to an extended position. Novelty lies in the creation of a locking hinge which allows compact storage and easy assembly of structural members having a minimal number of parts.
Official Gazette of the U.S. Patent and Trademark Office

N88-23979* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
BI-STEM GRIPPING APPARATUS Patent
FRED G. SANDERS, inventor (to NASA) 9 Feb. 1988 7 p Filed 3 Jun. 1987 Supersedes N87-25586 (25 - 19, p 2616)
(NASA-CASE-MFS-28185-1; US-PATENT-4,723,800; US-PATENT-APPL-SN-056930; US-PATENT-CLASS-294-16; US-PATENT-CLASS-294-106; US-PATENT-CLASS-294-113; US-PATENT-CLASS-294-119.2) Avail: US Patent and Trademark Office CSCL 13I

This invention relates to devices which grip cylindrical structures and more particularly to a device which has three arcuate gripping members having frictional surfaces for gripping and compressing a bi-stem. The bi-stem gripping apparatus is constructed having a pair of side gripping members, and an intermediate gripping member disposed between them. Sheets of a gum stock silicone rubber with frictional gripping surfaces are bonded to the inner region of the gripping members and provide frictional engagement between the bi-stem and the apparatus. A latch secures the gripping apparatus to a bi-stem and removable handles are attached, allowing an astronaut to pull the bi-stem from its cassette. A tethering ring on the outside of the gripping apparatus provides a convenient point to which a lanyard may be attached.
Official Gazette of the U.S. Patent and Trademark Office

N88-28958* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
EXPANDABLE PALLET FOR SPACE STATION INTERFACE ATTACHMENTS Patent
CLARENCE J. WESSELSKI, inventor (to NASA) 23 Aug. 1988 11 p Filed 13 Nov. 1986 Supersedes N87-18597 (25 - 11, p 1446)
(NASA-CASE-MSC-21117-1; US-PATENT-4,765,114; US-PATENT-APPL-SN-929875; US-PATENT-CLASS-52-646; US-PATENT-CLASS-52-648) Avail: US Patent and Trademark Office CSCL 22B

Described is a foldable expandable pallet for Space Station interface attachments with a basic square configuration. Each pallet consists of a series of struts joined together by node point fittings to make a rigid structure. The struts have hinge fittings which are spring loaded to permit collapse of the module for stowage transport to a Space Station in the payload bay of the Space Shuttle, and development on orbit. Dimensions of the pallet are selected to provide convenient, closely spaced attachment points between the node points of the relatively widely spaced trusses of a Space Station platform. A pallet is attached to a strut at four points: one close fitting hole, two oversize holes, and a slot to allow for thermal expansion/contraction and for manufacturing tolerances. Applications of the pallet include its use in rotary or angular joints; servicing of splints; with gridded plates; as instrument mounting bases; and as a roadbed for a Mobile Service Center (MSC). Official Gazette of the U.S. Patent and Trademark Office

N88-29180* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
COLLET LOCK JOINT FOR SPACE STATION TRUSS Patent
CLARENCE J. WESSELSKI, inventor (to NASA) 16 Aug. 1988 13 p Filed 1 Apr. 1987 Supersedes N87-25576 (25 - 19, p 2615)
(NASA-CASE-MSC-21207-1; US-PATENT-4,763,459; US-PATENT-APPL-SN-032818; US-PATENT-CLASS-52-646; US-PATENT-CLASS-52-648; US-PATENT-CLASS-403-217; US-PATENT-CLASS-403-171) Avail: US Patent and Trademark Office CSCL 13I

A lock joint for a Space Station has a series of struts joined together in a predetermined configuration by node point fittings. The fittings have removeable inserts. The lock joint has an elongated housing connected at one end to a strut. A split-fingered collet is mounted within the housing to insure reciprocal movement. A handle on the housing is connected to the collet for moving the collet into the insert where the fingers of the collet expand to lock the joint to the fitting.
Official Gazette of the U.S. Patent and Trademark Office

N88-30130*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CLEVIS JOINT FOR DEPLOYABLE SPACE STRUCTURES Patent Application
MARVIN D. RHODES, inventor (to NASA) 28 Jul. 1988 13 p (NASA-CASE-LAR-13898-1; NAS 1.71:LAR-13898-1; US-PATENT-APPL-SN-225427) Avail: NTIS HC A03/MF A01 CSCL 13K

This invention relates generally to pin clevis joints, and more particularly, to zero play pin clevis joints for connecting structural members of a deployable space structure. A joint includes a pin, a tang, and a shackle. The pin is tapered at the same angle as the bores extending through the projections of the shackle and the tang. A spring washer biases the tang onto the tapered sidewall of the pin. The invention solves the free play problem associated with deployable space structures by using a tapered pin which is held in tapered holes by the spring washers. NASA

04

STRUCTURAL AND THERMAL ANALYSIS

Includes structural analysis and design, thermal analysis and design, analysis and design techniques, and thermal control systems.

A88-34539* Space Telescope Science Inst., Baltimore, MD.
SPACE TEN-METER TELESCOPE (STMT) - STRUCTURAL AND THERMAL FEASIBILITY STUDY OF THE PRIMARY MIRROR
PIERRE Y. BELY (Space Telescope Science Institute, Baltimore, MD), JOHN F. BOLTON, STEVEN P. NEECK (NASA, Goddard Space Flight Center, Greenbelt, MD), and PHILIP J. TULKOFF (Swales and Associates, Inc., Beltsville, MD) IN: Reflective optics; Proceedings of the Meeting, Los Angeles, CA, Jan. 15, 16, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 29-36. refs

The structural and thermal behavior of a ten-meter primary mirror for a space optical/near-IR telescope in geosynchronous orbit is studied. The glass-type lightweighted mirror is monolithic, of the double arch type, and is supported at only three points. The computer programs SSPTA (thermal), NASTRAN (finite element), and ACCOS V (optical) are used in sequence to determine the temperature, deformation, and optical performance of the mirror. A mirror temperature of 130 K or less appears to be obtainable by purely passive means. With a fused silica or standard Zerodur blank, thermally-induced deformation is unacceptable and cannot be fully corrected by an active secondary mirror over the desired field. Either active thermal control or a blank of lower thermal expansion coefficient would be required. Author

A88-37295#
TWO-PHASE THERMAL LOOPS FOR USE IN FUTURE SPACECRAFT
HANS GEORG WULZ and RALF SIEPMANN Dornier-Post (English Edition) (ISSN 0012-5563), no. 1, 1988, p. 49-51.

In the two-phase thermal loops being developed by ESA for high heat-load space transport systems, such as the Space Shuttle and Spacelab, the working fluid is evaporated in the heat-absorbing 'cold plate' elements, whence it flows in vapor form to a radiator-like heat sink to be condensed as the heat is radiated into space. Attention is presently given to the design features and performance capabilities thus far experimentally established for mechanically-pumped, capillary-pumped, and hybrid versions of the two-phase loop. The hybrid thermal loops are especially promising for use aboard satellites with severe microgravity requirements. O.C.

A88-38672#
RELIABILITY EVALUATION ON ON-BOARD SATELLITE ANTENNA DEPLOYMENT MECHANISM
MASAYOSHI MISAWA, SHOJIRO MIYAKE, and TETSUO YASAKA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 410, 1988, p. 125-130. In Japanese, with abstract in English. refs

A procedure is proposed to evaluate the reliability of the antenna deployment mechanism for large satellite antennas. Failure mode and effects analysis is conducted to identify all possible failure modes. The bearing performance and friction are found to be critical. Test results show that the deployment and friction torque distributions can be assumed as normal distributions. The deployment reliability of the ADM is calculated based on these distributions. A method for preventing failure derived from the reduction in bearing clearance is also described. C.D.

A88-40292* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SHAPES - SPATIAL, HIGH-ACCURACY, POSITION-ENCODING SENSOR FOR MULTI-POINT, 3-D POSITION MEASUREMENT OF LARGE FLEXIBLE STRUCTURES
N. M. NERHEIM (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: 1987 SEM Spring Conference on Experimental Mechanics, Houston, TX, June 14-19, 1987, Proceedings. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 596-601.

An electro-optical position sensor for precise simultaneous measurement of the 3-D positions of multiple points on large space structures is described. The sensor data rate is sufficient for most control purposes. Range is determined by time-of-flight correlation of short laser pulses returned from retroreflector targets using a streak tube/CCD detector. Angular position is determined from target image locations on a second CCD. Experimental verification of dynamic ranging to multiple targets is discussed. Author

A88-41414#
CALORIMETRIC MEASUREMENTS OF THERMAL CONTROL SURFACES AT GEOSYNCHRONOUS ORBIT
C. C. ANDERSON and M. M. HATTAR (Aerojet ElectroSystems Co., Azusa, CA) Journal of Thermophysics and Heat Transfer

(ISSN 0887-8722), vol. 2, April 1988, p. 145-151. Previously cited in issue 19, p. 2956, Accession no. A87-43082. refs
(Contract F04701-84-C-0034)

A88-42441* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LONG-LIVED THERMAL CONTROL MATERIALS FOR HIGH TEMPERATURE AND DEEP SPACE APPLICATIONS
ROBIN WHITT and TIM O'DONNELL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1773-1786.
(Contract NAS7-918)

Considerable effort has been put into developing thermal-control materials for the Galileo space-craft. This paper presents a summary of these findings to date with emphasis on requirements, testing and results for the post-Challenger Galileo mission. Polyimide film (Kapton), due to its inherent stability in vacuum, UV, and radiation environments, combined with good mechanical properties over a large temperature range, has been the preferred substrate for spacecraft thermal control materials. Composite outer layers, using Kapton substrates, can be fabricated to meet the requirements of severe space environments. Included in the processing of Kapton-based composite outer layers can be the deposition of metal oxide, metallic and/or polymeric thin-film coatings to provide desirable electrical, optical and thermo-optical properties. In addition, reinforcement of Kapton substrates with fabrics and films is done to improve mechanical properties. Also these substrates can be filled with varying amounts of carbon to achieve particular electrical properties. The investigation and material development reported on here has led to improved thermo-gravimetric stability, surface conductivity, RF transparency, radiation and UV stability, flammability and handle-ability of outer layer thermal control materials for deep space and near-sun spacecraft. Designing, testing, and qualifying composite thermal-control film materials to meet the requirements of the Galileo spacecraft is the scope of this paper. Author

A88-42830#
SUPER HEAT PIPE DESIGN CONSIDERATIONS FOR APPLICATIONS TO SPACE-BASED SYSTEMS
F. DOBRAN (New York University, NY) IN: International Symposium on Thermal Problems in Space-Based Systems, Boston, MA, Dec. 13-18, 1987, Proceedings. New York, American Society of Mechanical Engineers, 1987, p. 1-12. refs

Current high heat-transfer-performance heat pipes are reviewed, and a super heat pipe designed to meet the reliability and heat transfer requirements of space-based systems is proposed. It is found that the axial heat transport capacity depends on the working fluid, the vapor flow area, the methods for both vapor introduction into the main core flow of the evaporator and vapor withdrawal from the condenser, and on the lengths of the evaporator, adiabatic, and condensor regions. Methods to suppress the axial heat transport limits are identified, in addition to design considerations for optimal boiling and wicking limits in heat pipes. R.R.

A88-42832#
APPLICABILITY OF THE FLOW-NET PROGRAM TO SOLUTION OF SPACE STATION FLUID DYNAMICS PROBLEMS
J. NAVICKAS (McDonnell Douglas Astronautics Co., Huntington Beach, CA) and W. C. RIVARD (Flow Science, Inc., Los Alamos, NM) IN: International Symposium on Thermal Problems in Space-Based Systems, Boston, MA, Dec. 13-18, 1987, Proceedings. New York, American Society of Mechanical Engineers, 1987, p. 19-24. refs

The Space Station design encompasses a variety of fluid systems that require extensive flow and combined flow-thermal analyses. The types of problems encountered range from two-phase cryogenic to high-pressure gaseous systems. Design of such systems requires the most advanced analytical tools. Because Space Station applications are a new area for existing two-phase flow programs, typically developed for nuclear safety applications, a careful evaluation of their capabilities to treat generic Space Station flows is appropriate. The results from an assessment of one particular program, FLOW-NET, developed by Flow Science, In., are presented. Three typical problems are analyzed: (1) fill of a hyperbaric module with gaseous nitrogen from a high-pressure supply system, (2) response of a liquid ammonia line to a rapid pressure decrease, and (3) performance of a basic two-phase, thermal control network. The three problems were solved successfully. Comparison of the results with those obtained by analytical methods supports the FLOW-NET calculations. Author

A88-42842#
APPLICATION OF TWO-PHASE THERMAL TRANSPORT SYSTEMS TO SPACE PLATFORMS
C. E. BRAUN, J. E. FREDLEY, V. J. GILBERTI, and K. HARTSHORN (RCA Aerospace and Defense, RCA Astro-Space Div., Princeton, NJ) IN: International Symposium on Thermal Problems in Space-Based Systems, Boston, MA, Dec. 13-18, 1987, Proceedings. New York, American Society of Mechanical Engineers, 1987, p. 125-134. refs

Increasingly stringent thermal requirements are projected for future spacecraft. Compliance with these requirements necessitates the development of thermal control techniques with capabilities far exceeding those in current use. A fundamental consideration is a heat acquisition, transport and rejection system capable for simultaneously accommodating large heat loads, high heat density sources, long transport distances, and varying operational parameters. This paper presents an overview of two-phase thermal transport systems and major components being developed for implementation in the forth-coming space platform era. Author

A88-42843#
ORBITAL REPLACEABLE UNIT-COLD PLATE DRY THERMAL INTERFACE CONCEPT AND TEST MEASUREMENTS
D. NIKANPOUR (British Aerospace, PLC, Space and Communications Div., Stevenage, England), H. K. SILL, and H. KREEB (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) IN: International Symposium on Thermal Problems in Space-Based Systems, Boston, MA, Dec. 13-18, 1987, Proceedings. New York, American Society of Mechanical Engineers, 1987, p. 135-139. ESA-supported research. refs

A cold plate to an ORU dry thermal interface design that would meet both the joint thermal performance of 5000 W/sq m K and allow easy replacement in space during repeated in-orbit servicing is proposed. The present concept involves a cylindrical arrangement of flexible outer heat pipes which are pneumatically forced onto a central inner heat pipe. A thin coating of a low melting point alloy on the heat pipes provides a detachable continuous thermal path across the joint and allows the performance requirements to be achieved even in the case of failure of the pressure. R.R.

A88-43743#
A FLEXIBLE VARIABLE CONDUCTANCE HEAT PIPE DESIGN FOR TEMPERATURE CONTROL OF SPACECRAFT EQUIPMENT
HAN HWANGBO and T. E. JOOST (MRJ, Inc., Oakton, VA) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 7 p.
(AIAA PAPER 88-2680)

The paper describes a variable conductance heat pipe design with a flexible joint. The heat pipe is developed for temperature control of high power electronics using a deployable space radiator. The evaporator section of the heat pipe is attached to the baseplate of the electronics. The condenser section of the heat pipe and the reservoir of noncondensible gas are attached to the deployable radiator. During the ascent phase of the flight the radiator is stowed for minimum heat rejection. During the final orbit period the radiator is deployed for full operation. An analytical thermal model of a Flexible Variable Conductance Heat Pipe (FVCHP) is developed to predict the heat transport capacity and the location of th noncondensible gas front in the heat pipe. Also, transient performance of the FVCHP in an orbital environment with electrical feedback temperature control is predicted. The analysis results indicate that a FVCHP radiator can reject at least twice the heat of a single sided fixed radiator of the same size. Results also indicate that control of the evaporator within 75 + or - 5 F is feasible for a unit with 100 W dissipation using the FVCHP radiator design presented. Author

A88-43746*# Los Alamos National Lab., NM.

DEVELOPMENT OF AN INTEGRATED HEAT PIPE-THERMAL STORAGE SYSTEM FOR A SOLAR RECEIVER

E. KEDDY, J. TOM SENA, M. MERRIGAN (Los Alamos National Laboratory, NM), GARY HEIDENREICH (Sundstrand Corp., Rockford, IL), and STEVE JOHNSON (NASA, Lewis Research Center, Cleveland, OH) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 6 p.
(AIAA PAPER 88-2683)

An integrated heat pipe-thermal storage system was developed as part of the Organic Rankine Cycle Solar Dynamic Power System solar receiver for space station application. The solar receiver incorporates potassium heat pipe elements to absorb and transfer the solar energy within the receiver cavity. The heat pipes contain thermal energy storage (TES) canisters within the vapor space with a toluene heater tube used as the condenser region of the heat pipe. During the insolation period of the earth orbit, solar energy is delivered to the heat pipe. Part of this thermal energy is delivered to the heater tube and the balance is stored in the TES units. During the eclipse period of earth orbit, the stored energy in the TES units is transferred by the potassium vapor to the toluene heater tube. A developmental heat pipe element was constructed that contains axial arteries and a distribution wick connecting the toluene heater and the TES units to the solar insolation surface of the heat pipe. Tests were conducted to demonstrate the heat pipe, TES units, and the heater tube operation. The heat pipe element was operated at design input power of 4.8 kW. Thermal cycle tests were conducted to demonstrate the successful charge and discharge of the TES units. Axial power flux levels up to 15 watts/sq cm were demonstrated and transient tests were conducted on the heat pipe element. Details of the heat pipe development and test procedures are presented. Author

A88-43753#

TWO-PHASE AMMONIA THERMAL BUS PERFORMANCE

TED J. KRAMER, DONALD L. MYRON, and MICHAEL P. MCHALE (Boeing Aerospace Co., Seattle, WA) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 13 p. refs
(AIAA PAPER 88-2701)

This paper describes the results of a series of tests that explored the performance of an ammonia heat transport system being developed for future spacecraft applications. It was found that the self-controlling system maintained stable evaporative cold plate temperatures over a wide range of heat loads and heat sink temperatures. The ability of the system to control heat load temperatures during burst power inputs to the evaporator was demonstrated. It was shown that the system required no thermal conditioning or special procedures to start; and reached set point control temperatures within 3.5 minutes of startup under heat load. It was also shown that set point temperatures could be changed and set point control maintained during system operation. Author

A88-43754*# OAO Corp., Greenbelt, MD.

A HIGH POWER SPACECRAFT THERMAL MANAGEMENT SYSTEM

J. KU, E. J. KROLICZEK (OAO Corp., Greenbelt, MD), M. E. MCCABE, JR. (NASA, Goddard Space Flight Center, Greenbelt, MD), and S. M. BENNER (TS Infosystems, Inc., Lanham, MD) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 12 p. refs
(AIAA PAPER 88-2702)

This paper describes the design and test results of an ammonia hybrid capillary pumped loop thermal control system. As a hytbrid, the system can operate as either a passive, capillary pumped loop, or, as a mechanically pumped system. The system is comprised of an evaporator section, a condenser section, 10 meters of liquid and vapor transport lines, a mechanical pump, and a reservoir. In the evaporator section, four capillary pumps are each integrated into three cold plates. The mechanical pump is installed in the liquid line and is in series with the capillary pumps. Testing has demonstrated that in the capillary pumped mode, the HPS™ can acquire and transport a total heat load of between 120 W and 24 kW, with a maximum heat flux density of 4.3 W/sq cm in the evaporator section. In the mechanically pumped configuration, a heat acquisition potential of 50 kW (9 W/sq cm heat flux density) has been demonstrated. The hybrid system still retains the proven capillary capabilities of temperature control, heat load sharing and fluid flow control between evaporator plates, rapid power cycling, and pressure priming recovery of deprimed evaporators. Author

A88-44785#

ROTATING SOLID RADIATIVE COOLANT SYSTEM FOR SPACE NUCLEAR REACTORS

WALTER J. APLEY (Pacific Northwest Laboratory, Richland, WA) and ALBERT L. BABB (Washington, University, Seattle) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p. refs
(Contract DE-AC06-76RL-01830)
(AIAA PAPER 88-3189)

The RING power system described in this paper is proposed as a primary or emergency heat rejection system for advanced space reactor power applications. The system employs a set of four (4) counter-rotating, 90 degree offset, coolant-carrying rings. The rings (segmented, corrugated, finned, thin-walled pipes, filled with liquid lithium) pass through a cavity heat exchanger and re-radiate the absorbed heat to the space environment. Author

A88-46402* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

CONTINUUM MODELING OF LARGE LATTICE STRUCTURES - STATUS AND PROJECTIONS

AHMED K. NOOR and MARTIN M. MIKULAS (NASA, Langley Research Center, Hampton, VA) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 1-34. Previously announced in STAR as N88-14115. refs
(Contract NAG1-740)

The status and some recent developments of continuum modeling for large repetitive lattice structures are summarized. Discussion focuses on a number of aspects including definition of an effective substitute continuum; characterization of the continuum model; and the different approaches for generating the properties of the continuum, namely, the constitutive matrix, the matrix of mass densities, and the matrix of thermal coefficients. Also, a simple approach is presented for generating the continuum properties. The approach can be used to generate analytic and/or numerical values of the continuum properties. Author

A88-46404* Purdue Univ., West Lafayette, IN.

MODAL COST ANALYSIS FOR SIMPLE CONTINUA

A. HU, R. E. SKELTON, and T. Y. YANG (Purdue University, West Lafayette, IN) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 71-94. refs
(Contract NAG1-642)

The most popular finite element codes are based upon appealing theories of convergence of modal frequencies. For example, the popularity of cubic elements for beam-like structures is due to the rapid convergence of modal frequencies and stiffness properties. However, for those problems in which the primary consideration is the accuracy of response of the structure at specified locations, it is more important to obtain accuracy in the modal costs than in the modal frequencies. The modal cost represents the contribution of a mode in the norm of the response vector. This paper provides a complete modal cost analysis for simple continua such as beam-like structures. Upper bounds are developed for mode truncation errors in the model reduction process and modal cost analysis dictates which modes to retain in order to reduce the model for control design purposes. Author

A88-48479#

CRITIQUE OF THE THERMAL DESIGN VERIFICATION PROGRAM FOR A HIGH-POWER COMMUNICATIONS SPACECRAFT

P. C. WISE (General Electric Co., Astro-Space Div., Princeton, NJ), W. H. KELLY (COMSAT Laboratories, Clarksburg, MD), and S. P. SHARMA (COMSAT, Space Communications Div., Princeton, NJ) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 8 p.
(AIAA PAPER 88-2648)

This paper describes the programmatic and technical trade-offs used to define a thermal-control-subsystem verification-test program for a high-power communications spacecraft employing heat pipes. Benefits derived from a qualification thermal/mechanical model are critically reviewed. An overview of requirements for and constraints on unit- and spacecraft-level testing involving the use of heat pipes is presented. Finally, the test techniques used to measure thermal distortion of the deployed antenna reflector dish are described. Author

A88-49658

DYNAMIC ANALYSIS OF FINITELY STRETCHED AND ROTATED THREE-DIMENSIONAL SPACE-CURVED BEAMS

M. IURA and S. N. ATLURI (Georgia Institute of Technology, Atlanta) Computers and Structures (ISSN 0045-7949), vol. 29, no. 5, 1988, p. 875-889. refs
(Contract F49620-87-C-0064)

The problem of transient dynamics of highly flexible three-dimensional space-curved beams undergoing large rotations and stretches, is treated. The case of conservative force loading, which may also lead to configuration-dependent moments on the beam, is considered. Using the three parameters associated with a conformal rotation-vector representation of finite rotations, a well-defined Hamilton functional is established for the flexible beam undergoing finite rotations and stretches. A Newmark time-integration scheme is used to integrate the semi-discrete finite-element equations in time. Several examples of transient dynamic response of highly flexible beam-like structures including those in free flight, are presented to illustrate the validity of the theoretical methodology. Author

A88-50339#

OPTIMAL STRUCTURAL DESIGN WITH CONTROL GAIN NORM CONSTRAINT

N. S. KHOT, V. B. VENKAYYA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), H. OZ (Ohio State University, Columbus), R. V. GRANDHI (Wright State University, Dayton, OH), and F. E. EASTEP (Dayton, University, OH) AIAA Journal (ISSN 0001-1452), vol. 26, May 1988, p. 604-611. Previously cited in issue 08, p. 1144, Accession no. A87-22363. refs

A88-50873

COMPARISON OF THEORETICAL AND EXPERIMENTAL MODAL ANALYSIS RESULTS OF A RECTANGULAR THREE DIMENSIONAL FRAME

R. SAMUEL, R. K. RAMANATHAN, S. SHANKARNARAYANAN, and K. H. NAVALGUND (ISRO, Satellite Centre, Bangalore, India) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1214-1218.

The spacecraft structures are qualified using base excitation on a shaker system whereas experimental modal analysis is done using Single Point Random (SPR) method. Experimental (SPR and base excitation) and theoretical results show good agreement for a simple three dimensional frame with fixed boundary condition and these results are presented in this paper. Author

A88-53220* Cryolab, Inc., San Luis Obispo, CA.

BAYONET FOR SUPERFLUID HELIUM TRANSFER IN SPACE

G. E. MCINTOSH, D. S. LOMBARD, D. L. MARTINDALE (Cryolab, Inc., San Luis Obispo, CA), and MICHAEL J. DIPIRRO (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Advances in cryogenic engineering. Volume 33 - Proceedings of the Cryogenic Engineering Conference, Saint Charles, IL, June 14-18, 1987. New York, Plenum Press, 1988, p. 885-891.
(Contract NAS5-29224)

A prototype superfluid helium bayonet for potential space applications has been developed and evaluated with a low heat leak test apparatus. Measured heat leak of the 13 mm (1/2 inch) bayonet pair is 0.21 W at 1.8 K with an uncertainty of +0.09/-0.05 W. Bayonets are fabricated with thin, electron beam (EB) welded tubes which are EB welded to machined nose and flange pieces. Low heat leak structural integrity is provided by a 0.9 mm thickness of filament wound fiberglass-epoxy. Superfluid creep is restricted by KEL-F nose seals which form vacuum-tight extensions to the bayonet cold end pieces. Author

N88-20599*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

CRYOGENIC FLUID MANAGEMENT TECHNOLOGY WORKSHOP. VOLUME 2: ROUNDTABLE DISCUSSION OF TECHNOLOGY REQUIREMENTS

Mar. 1988 84 p Workshop held in Cleveland, Ohio, 28-30 Apr. 1987
(NASA-CP-10009; E-3987; NAS 1.55:10009) Avail: NTIS HC A05/MF A01 CSCL 20D

The Cryogenic Fluid Management Technology Workshop was held April 28 to 30, 1987, at the NASA Lewis Research Center in Cleveland, Ohio. The major objective of the workshop was to identify future NASA needs for technology concerning the management of subcritical cryogenic fluids in the low-gravity space environment. In addition, workshop participants were asked to identify those technologies which will require in-space experimentation and thus are candidates for inclusion in the flight experiment being defined at Lewis. The principal application for advanced fluid management technology is the Space-Based Orbit Transfer Vehicle (SBOTV) and its servicing facility, the On-Orbit Cryogenic Fuel Depot (OOCFD). Other potential applications include the replenishment of cryogenic coolants (with the exception of superfluid helium), reactants, and propellants on board a variety of spacecraft including the space station and space-based weapon systems. The last day was devoted to a roundtable discussion of cryogenic fluid management technology requirements by 30 representatives from NASA, industry, and academia. This volume contains a transcript of the discussion of the eight major technology categories. Author

N88-21492*# Lockheed Missiles and Space Co., Sunnyvale, CA.

AMMONIA TRANSFER ACROSS ROTATING JOINTS IN SPACE

MARK H. WARNER *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium p 341-353 May 1988
Avail: NTIS HC A18/MF A01 CSCL 20D

Thermal control of future large space facilities, such as the space station, will require the transfer of anhydrous ammonia across rotating joints with near zero leakage. Anhydrous ammonia is the primary heat transfer fluid aboard the station, providing critical thermal management of habitat and payload systems. The solar radiator joints, as well as the various payload pointing systems, are obvious examples of the need for a reliable fluid transfer device. Low weight, tight temperature control, low parasitic drag torque, long life, and high reliability, in addition to near zero leakage, are important characteristics necessary for the successful operation of such a device. In late 1986, Lockheed initiated a project to develop a Rotary Transfer Coupling (RTC) directed toward space station requirements. Fabrication and assembly of this device is now complete and testing is scheduled. The design and development of the face seal-type rotary fluid coupling that utilizes a unique cover gas concept (an inert gas such as nitrogen) to provide full containment of the ammonia was addressed. Author

N88-22321# Boeing Aerospace Co., Seattle, WA.
FLOSIN: A FLUID LOOP ANALYZER FOR SINDA
STEVEN M. LUNDE 1988 11 p Presented at the SAE 18th Intersociety Conference on Environment Systems
Avail: NTIS HC A03/MF A01

High-power heat transport systems for large space platforms require the use of complex fluid loops to effectively and efficiently move waste heat energy from source to sink. In particular, use of two-phase heat acquisition and transport systems offers significant advantages such as reduction of pump power, automation of control systems, constant sink temperatures at the load, and flexible load placement. Analytical tools are needed for design analysis and performance prediction of these systems. Moreover, environmental considerations and insulation systems need to be taken into account, especially when subcooling and superheating become important parameters in the overall design. The development and use of FLOSIN, a system-level, two-phase fluid loop analyzer, are discussed. Explained are the modeling approach for systems utilizing Rotary Fluid Management Device (RFMD), Back Pressure Regulating Valve (BPRV), and cavitating venturis. Described are the unique components and special subroutines for processing input and output, for handling flow splits, and for generating Systems Improved Numerical Differencing Analyzer (SINDA) thermal networks. Author

N88-22406*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STRUCTURAL ASSESSMENT OF A SPACE STATION SOLAR DYNAMIC HEAT RECEIVER THERMAL ENERGY STORAGE CANISTER
R. L. THOMPSON, T. W. KERSLAKE, and M. T. TONG (Sverdrup Technology, Inc., Cleveland, Ohio.) *In its* Lewis Structures Technology, 1988. Volume 2: Structural Mechanics p 281-294 May 1988 Previously announced in IAA as N88-31396
Avail: NTIS HC A14/MF A01 CSCL 20K

The structural performance of a space station thermal energy storage (TES) canister subject to orbital solar flux variation and engine cold start up operating conditions was assessed. The impact of working fluid temperature and salt-void distribution on the canister structure are assessed. Both analytical and experimental studies were conducted to determine the temperature distribution of the canister. Subsequent finite element structural analyses of the canister were performed using both analytically and experimentally obtained temperatures. The Arrhenius creep law was incorporated into the procedure, using secondary creep data for the canister material, Haynes 188 alloy. The predicted cyclic creep strain accumulations at the hot spot were used to assess the structural performance of the canister. In addition, the structural performance of the canister based on the analytically determined temperature was compared with that based on the experimentally measured temperature data. Author

N88-23182*# Grumman Aerospace Corp., Bethpage, NY.
SOLAR DYNAMIC HEAT REJECTION TECHNOLOGY. TASK 2: HEAT PIPE RADIATOR DEVELOPMENT Final Report
MARK LEAGUE and JOE ALARIO May 1988 46 p
(Contract NAS3-24665)
(NASA-CR-182141; NAS 1.26:182141) Avail: NTIS HC A03/MF A01 CSCL 20D

This report covers the design, fabrication, and test of several dual slot heat pipe engineering development units. The following dual-slot heat pipes were fabricated and tested: two 6-ft. aluminum heat pipes; a 20-ft. aluminum heat pipe; and a 20-ft. aluminum heat pipe with a four-leg evaporator section. The test results of all four test articles are presented and compared to the performance predicted by the design software. Test results from the four-leg article are incomplete. The methodology for fabricating stainless steel dual slot heat pipes was also studied by performing a tool life test with different single point cutters, and these results are also presented. Although the dual-slot heat pipe has demonstrated the potential to meet the requirements for a high capacity radiator system, uncertainties with the design still exist. The startup difficulties with the aluminum test articles must be solved, and a stainless steel/methanol heat pipe should be built and tested. Author

N88-24672*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
STRUCTURAL MARGINS ASSESSMENT APPROACH
ROBERT S. RYAN Jun. 1988 56 p
(NASA-TM-100332; NAS 1.15:100332) Avail: NTIS HC A04/MF A01 CSCL 22B

A general approach to the structural design and verification used to determine the structural margins of the space vehicle elements under Marshall Space Flight Center (MSFC) management is described. The Space Shuttle results and organization will be used as illustrations for techniques discussed. Given also are: (1) the system analyses performed or to be performed by, and (2) element analyses performed by MSFC and its contractors. Analysis approaches and their verification will be addressed. The Shuttle procedures are general in nature and apply to other than Shuttle space vehicles. Author

N88-26389*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
DESIGN AND TESTING OF A HIGH POWER SPACECRAFT THERMAL MANAGEMENT SYSTEM
MICHAEL E. MCCABE, JR., JENTUNG KU, and STEVE BENNER (TS Infosystems, Lanham, Md.) Jun. 1988 109 p Sponsored in part by AF
(Contract NAS5-28626)
(NASA-TM-4051; REPT-88B0167; NAS 1.15:4051) Avail: NTIS HC A06/MF A01 CSCL 22B

The design and test results are presented of an ammonia hybrid capillary pumped loop thermal control system which could be used for heat acquisition and transport on future large space platforms and attached payloads, such as those associated with the NASA Space Station. The High Power Spacecraft Thermal Management System (HPSTM) can operate as either a passive, capillary pumped two phase thermal control system, or, when additional pressure head is required, as a mechanically pumped loop. Testing has shown that in the capillary mode, the HPSTM evaporators can acquire a total heat load of between 600 W and 24 kW, transported over 10 meters, at a maximum heat flux density of 4.3 W/sq cm. With the mechanical pump circulating the ammonia, a heat acquisition potential of 52 kW was demonstrated for 15 minutes without an evaporator failure. These results represent a significant improvement over the maximum transport capability previously displayed in other capillary systems. The HPSTM system still retains the proven capillary capabilities of heat load sharing and flow control between evaporator plates, rapid power cycling, and nonuniform heating in both the capillary and hybrid operating modes. Author

N88-29128# Societe Nationale Industrielle Aerospatiale, Cannes (France).
DEVELOPMENT OF A SPACE DEPLOYABLE RADIATOR USING HEAT PIPES
M. AMDIEU, B. MOSCHETTI, and M. B. TATRY (Centre National d'Etudes Spatiales, Toulouse, France) 25 Mar. 1988 7 p
(SNIAS-881-440-104; ETN-88-92874) Avail: NTIS HC A02/MF A01

A space radiator using heat pipes prototype model with a deployable radiator connected to a rotating thermal joint was designed, built, and tested. Performance tests were conducted on the model to measure deployment torque, and verifiy the thermal performance (globally and for each of the components). The good results of these tests show that this radiator can be adapted to all kinds of satellites and space platforms. ESA

N88-29395*# Georgia Inst. of Tech., Atlanta. School of Electrical Engineering.
REASONING ABOUT FAULT DIAGNOSIS FOR THE SPACE STATION COMMON MODULE THERMAL CONTROL SYSTEM
G. VACHTSEVANOS, H. HEXMOOR, and B. PURVES (Boeing

Aerospace Co., Huntsville, Ala.) *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 403-412 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 22B

The proposed common module thermal control system for the Space Station is designed to integrate thermal distribution and thermal control functions in order to transport heat and provide environmental temperature control through the common module. When the thermal system is operating in an off-normal state, due to component faults, an intelligent controller is called upon to diagnose the fault type, identify the fault location and determine the appropriate control action required to isolate the faulty component. A methodology is introduced for fault diagnosis based upon a combination of signal redundancy techniques and fuzzy logic. An expert system utilizes parity space representation and analytic redundancy to derive fault symptoms, the aggregate of which is assessed by a multivalued rule based system. A subscale laboratory model of the thermal control system designed is used as the testbed for the study. Author

N88-30181*# Lockheed Missiles and Space Co., Sunnyvale, CA.
ADVANCED PLANAR ARRAY DEVELOPMENT FOR SPACE STATION Final Report, 1 Jun. 1985 - 1 Jun. 1987
Jun. 1987 101 p
(Contract NAS8-36419)
(NASA-CR-179373; NAS 1.26:179373; LMSC-F115808) Avail: NTIS HC A05/MF A01 CSCL 10B

The results of the Advanced Planar Array Development for the Space Station contract are presented. The original objectives of the contract were: (1) to develop a process for manufacturing superstrate assemblies, (2) to demonstrate superstrate technology through fabrication and test, (3) to develop and analyze a preliminary solar array wing design, and (4) to fabricate a wing segment based on wing design. The primary tasks completed were designing test modules, fabricating, and testing them. LMSC performed three tasks which included thermal cycle testing for 2000 thermal cycles, thermal balance testing at the Boeing Environmental Test Lab in Kent, Washington, and acceptance testing a 15 ft x 50 in panel segment for 100 thermal cycles. The surperstrate modules performed well during both thermal cycle testing and thermal balance testing. The successful completion of these tests demonstrate the technical feasibility of a solar array power system utilizing superstrate technology. This final report describes the major elements of this contract including the manufacturing process used to fabricate modules, the tests performed, and the results and conclusions of the tests. Author

N88-30552# Contraves Corp., Zurich (Switzerland). Space Dept.
FAR INFRARED SPECTROSCOPY TELESCOPE (FIRST) INFLATABLE THERMAL SHIELD, PHASE 1 Final Report
S. KOSE Paris, France ESA Jun. 1987 197 p
(Contract ESA-6324/85-NL-PB(SC))
(SR/FIS/108(87)CZ; ESA-CR(P)-2568; ETN-88-93017) Avail: NTIS HC A09/MF A01

Inflatable space rigidized structures (ISRS) were assessed for the FIRST satellite thermal shield. The baseline shield configuration, the so called obliquely cut cylindrical shield configuration, has a diameter of 10 m, a maximum height of 10 m, and a cut angle of 30 deg. This shield consists of an ISRS skeleton of tubes of diameter 0.45 m carrying the thermal control layers. The stringent requirements on the thermal control can be met by a 6-layer multilayer insulation, consisting of 2 layers of SAK (1 Mil) and 4-layers of DAM (0.25 Mil). Using the BF3 catalyst, the ISRS structure can be cured in 3 preselected positions with respect to Sun within 9 hr. Curing without catalyst is also possible, but in this case a 90 deg tilt of the satellite and longer cure times (24 hr) must be faced. The first eigenfrequency of the baseline thermal shield in deployed configuration is 2.15 Hz, thus the stiffness requirement is fulfilled. The thermal shield can survive the thermal stresses introduced during the worst operational case. The total mass lies comfortably within the specified limit of 220 kg. The shield can be well stowed in the allowable volume of the Ariane 4 shroud. ESA

05

STRUCTURAL DYNAMICS AND CONTROL

Includes modeling, systems identification, attitude and control techniques and systems, surface accuracy measurement and control techniques and systems, sensors, and actuators.

A88-33104
EFFECT OF SOLAR PRESSURE ON THE MOTION AND STABILITY OF THE SYSTEM OF TWO INTER-CONNECTED SATELLITES IN AN ELLIPTICAL ORBIT
SACHINDRA KUMAR SINHA (Rajendra Agricultural University, Pusa Samastiupur, India) and R. B. SINGH (Bihar University, Muzaffarpur, India) Astrophysics and Space Science (ISSN 0004-640X), vol. 140, no. 1, Jan. 1988, p. 49-54. refs

The effect of solar pressure on the motion and stability of a system of two interconnected satellites (such as a manned-space capsule attached to its booster with a flexible and inextensible string near some equilibrium position) is investigated analytically for the case of elliptical orbit. In this model, which is based on the work of Beletsky (1965, 1969), Singh (1973), and Sinha (1987), the equations of motion obtained are nonlinear and nonautomous; the solution of the system was obtained using Bogoliubov et al. (1961) method. The results indicate that the amplitude of the system remains constant up to the order of e-squared (where e denotes eccentricity). If the value of e is very small, the system will always oscillate about the position of equilibrium with tight string-like dumb-bell satellite with changing phase and constant amplitude. I.S.

A88-33446*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SYNTHESIS OF FINE-POINTING CONTROL SYSTEMS FOR LARGE, FLEXIBLE SPACECRAFT
SURESH M. JOSHI (NASA, Langley Research Center, Hampton, VA) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 171-176. refs

This paper considers the problem of designing attitude control systems for large space structures (LSS). The difficulties in control systems design, which arise because of special dynamic characteristics of LSS, are described, and methods for overcoming them using two types of controllers are presented. The first type of controller considered is a model-based compensator (MBC), and the second is the 'dissipative' controller which employs output feedback. Based on the numerical and analytical results obtained, the MBC can offer good performance under normal conditions, while the dissipative controller offers more robustness but perhaps reduced performance in situations involving large uncertainties. Author

A88-34498
LARGE SPACE OPTICAL SYSTEM ACTIVE VIBRATION SUPPRESSION
L. W. HODGE and J. A. BREAKWELL (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Structural mechanics of optical systems II; Proceedings of the Meeting, Los Angeles, CA, Jan. 13-15, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 106-113.

Large space optical system vibration suppression is presently undertaken through the assembly of an integrated optics/structures/controls simulation, in order to test the performance of the primary control system. This high authority control/low authority control (HAC/LAC) system's simulated performance for a defined suppression requirement encompassed a partially validated FEM model, the requisite optical performance algorithms, and a closed loop HAC/LAC model. The specified -40 dB requirements are met with actuators of minimal, 0.5-lb weight at eight locations, which cause no significant changes in either modal frequency or shape. O.C.

A88-34500
CONCEPTUAL DESIGN FOR ACTIVE STRUCTURAL CONTROL OF A LARGE OPTICAL SYSTEM
JEROME D. GOTTESMAN, GON-YEN SHEN, and SHIVA S. TRIPATHI (Perkin-Elmer Corp., Danbury, CT) IN: Structural mechanics of optical systems II; Proceedings of the Meeting, Los Angeles, CA, Jan. 13-15, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 126-135. refs

A design for the active structural control of a two-element laser beam expander is described. The lengths of selected struts of a trussed, quadrapod graphite/epoxy structure are monitored and controlled by sensor/actuators using a modal control technique with rate-damping enhancement. The details of structural design, optical arrangement, strut sensors and actuators, and control algorithms are discussed. Author

A88-34501
MULTIVARIABLE CONTROL LAW ANALYSIS FOR A LARGE SPACE ANTENNA
DALE F. ENNS and DANIEL J. BUGAJSKI (Honeywell Systems and Research Center, Minneapolis, MN) IN: Structural mechanics of optical systems II; Proceedings of the Meeting, Los Angeles, CA, Jan. 13-15, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 136-145. refs

This paper will discuss control laws for a large space antenna. The discussion will focus on analysis of the multivariable, closed loop system with respect to nominal performance, robust stability, and robust performance. The analysis employs singular values and structured singular values of multivariable frequency responses. Consistency between the frequency response analysis and time simulations is also presented. A simplified model of a large flexible space antenna was used for the analysis. Author

A88-34502
AN EXPERIMENTAL TEST-BED FOR VALIDATION OF CONTROL METHODOLOGIES IN LARGE SPACE OPTICAL STRUCTURES
DAVID C. HYLAND (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: Structural mechanics of optical systems II; Proceedings of the Meeting, Los Angeles, CA, Jan. 13-15, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 146-155. refs

This paper reviews an optics/vibration experiment involving the Harris Deployable Multi-Hex Prototype - a reflector structure comprising a seven-panel array. Design considerations needed to ensure the emulation of vibration pathologies characteristic of SDI systems are discussed. The key aspects of dynamic complexity, deployability and proper combination of generically distinct vibration suppression methods are emphasized. We describe the experimental setup which follows as a consequence of these considerations. The projected test plan emphasizes combined orchestration of active and passive methods. Author

A88-34613#
MODAL TESTING R&D AT THE COMMUNICATIONS RESEARCH CENTRE
Y. SOUCY, F. R. VIGNERON, and T. STEELE (CDC, Communications Research Centre, Ottawa, Canada) (Canadian Symposium on Aerospace Structures and Materials, 3rd, Ottawa, Canada, June 9-11, 1986) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 34, March 1988, p. 38-47. refs

In the last ten years, novel methods of parameter identification have been developed and modal testing technology has rapidly expanded, primarily as a result of the availability of low-cost, high-performance minicomputers and test equipment. Modal tests are broadly characterizable as phase-resonance and mode-separation methods; attention is presently given to the latter, in which one or more excitation devices are used to induce structure motions that contain all structural modes of interest. Projects of this kind that are presently discussed include the step-relaxation and driven-base excitation techniques for space structure parameter estimation, the testing of large, flexible space structures, and the evaluation of a substructure coupling method. O.C.

A88-34736
TIME OPTIMAL SLEWING OF FLEXIBLE SPACECRAFT
JOSEPH BEN-ASHER, JOHN A. BURNS, and EUGENE M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 524-528. refs
(Contract AF-AFOSR-85-0287)

The time-optimal slewing problem of flexible spacecraft is considered. The system is discretisized by the assumed-modes method, and the problem is solved for a linearized model in reduced state space by parameter optimization. Optimality is verified by the maximal principle. The linear solution is used to obtain time-optimal solutions for the nonlinear problem. I.E.

A88-34737
APPROXIMATION IN DISCRETE-TIME BOUNDARY CONTROL OF FLEXIBLE STRUCTURES
J. S. GIBSON (California, University, Los Angeles) and I. G. ROSEN (Southern California, University, Los Angeles, CA) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 535-540. refs
(Contract AF-AFOSR-84-0309; AF-AFOSR-84-0393)

The authors consider discrete-time LQG (linear quadratic Guassian) optimal control of flexible structures with boundary control and what normally are unbounded measurement operators. The application of recently developed approximation theory for infinite-dimensional discrete-time LQG problems to this problem is discussed. Numerical results are given for control of a flexible beam. I.E.

A88-34749
REDUCED-ORDER COMPENSATION: LQG REDUCTION VERSUS OPTIMAL PROJECTION USING A HOMOTOPIC CONTINUATION METHOD
S. W. GREELEY, D. C. HYLAND, and S. RICHTER (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 742-747. refs
(Contract F49620-84-C-0038)

The optimal projection method, as solved by a recently developed homotopy continuation algorithm, is considered. Design results obtained by different methods for forty-two design cases are compared with the results of the present method with respect to closed-loop stability. Only the optimal projection method produced stable designs for all cases. I.E.

A88-34790#
MOVING BANK MULTIPLE MODEL ADAPTIVE ESTIMATION APPLIED TO FLEXIBLE SPACE STRUCTURE CONTROL
DREW A. KARNICK and PETER S. MAYBECK (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1249-1257. refs

The feasibility of applying moving-bank multiple-model adaptive estimation algorithms to flexible-space-structure control is investigated. Moving-bank multiple-model adaptive estimation control is an attempt to reduce the computational load associated with the implementation of a full-scale multiple-model adaptive estimator/controller. It is shown that although the use of a moving bank can provide improved state estimation and control performance, similar performance can be obtained from a fixed-bank estimator with fewer filters than a full bank, accomplished through a coarse discretization that covers the range of parameter variation. I.E.

A88-34791
AN ADAPTIVE CONTROL SYSTEM FOR FINE POINTING OF FLEXIBLE SPACECRAFT
T. E. ELIAZOV (Bell Communications Research, Inc., Red Bank, NJ) and F. E. THAU (City College, New York) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1258-1262. refs

A least-squares algorithm is used to identify simultaneously the unknown states and parameters of a discrete-time lumped-parameter model of the flexible structure. The identified states and parameters form the input to a bang-off-bang control law that, in conjunction with the identification algorithm, results in an adaptive system whose response closely approximates that of a system with known parameters. Simulation studies demonstrate the response achievable with the proposed approach. I.E.

A88-34792
SYSTEM IDENTIFICATION FOR SPACE CONTROL LABORATORY EXPERIMENT (SCOLE) USING DISTRIBUTED PARAMETER MODELS
S. A. HOSSAIN and K. Y. LEE (Pennsylvania State University, University Park) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1263-1268. refs

An infinite-dimensional identification scheme to determine system parameters in large flexible structures in space is presented. The method retains the distributed nature of the structure throughout the development of the algorithm and a finite-element approximation is used only to implement the algorithm. This approach eliminates any problems associated with model truncation used in other methods of identification. The identification problem is formulated in Hilbert spaces and an optimal control technique is used to minimize weighted least squares of error between the actual and the model data. Computer simulation studies are conducted using a shuttle-attached antenna configuration, more popularly known as the Space Control Laboratory Experiment (SCOLE), as an example. Numerical results show a close match between the estimated and true values of the parameters. I.E.

A88-34794
ROTATIONAL MANEUVER AND STABILIZATION OF AN ELASTIC SPACECRAFT
SAHJENDRA N. SINGH (Nevada, University, Las Vegas) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1275-1280. refs

The question of attitude control and elastic mode stabilization of a spacecraft (orbiter) with beam/tip-mass-type payloads is considered. A three-axis moment control law is derived to control the attitude of the spacecraft. The derivation of the control moments acting on the spacecraft does not require any information on the system dynamics. The control law includes a reference model and a dynamic compensator in the feedback path. For damping out the elastic motion excited by the slewing maneuver, an elastic mode stabilizer is designed. The stabilization is achieved by modal velocity feedback using force and torque actuators located at the payload end of the elastic beam. Collocated actuators and sensors provide robust stabilization. I.E.

A88-34796*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONTROLLER SYNTHESIS FOR FLEXIBLE SPACECRAFT USING MULTIVARIABLE LOOP-SHAPING AND FACTORIZATION METHODS
SURESH M. JOSHI (NASA, Langley Research Center, Hampton, VA) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1288, 1289. refs

The problem of designing fine-pointing controllers is considered for large, flexible space structures using modern multivariable synthesis methods. The first method is an iterative procedure which utilizes frequency-domain singular-value techniques, and is found to yield satisfactory performance and robustness. For the second method, which is based on coprime factorizations, a particular bicoprime is obtained, and the steps in the design process are described. This method is still under development. I.E.

A88-34805* Brown Univ., Providence, RI.
PARAMETER IDENTIFICATION TECHNIQUES FOR THE ESTIMATION OF DAMPING IN FLEXIBLE STRUCTURE EXPERIMENTS
H. T. BANKS, Y. WANG (Brown University, Providence, RI), D. J. INMAN, and H. CUDNEY, JR. (New York, State University, Buffalo) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1392-1395. refs
(Contract NAG1-517; AF-AFOSR-84-0398; AF-AFOSR-85-0220; NSF MSM-83-51807; AF-AFOSR-85-01)

The use of spline-based inverse procedures to estimate damping coefficients for flexible structures in distributed-parameter systems is reported. Damping models involving viscous (air) damping and Kelvin-Voigt damping in an Euler-Bernoulli framework are used to analyze data from vibration experiments with composite material beams. I.E.

A88-34812
TIME OPTIMAL SLEWING OF A RIGID BODY WITH FLEXIBLE APPENDAGES
G. SINGH, P. T. KABAMBA, and N. H. MCCLAMROCH (Michigan, University, Ann Arbor) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1441, 1442. refs

The control problem of time-optimal, rest-to-rest, slewing of a rigid body with flexible appendages through a large angle is considered. A finite-dimensional time-optimal slewing problem is proposed as a relaxation of an ill-posed infinite-dimensional time-optimal slewing problem. The optimal control history is shown to have an important time symmetry property. The switching times, final time, and costates at midmaneuver are shown to satisfy a system of nonlinear algebraic equations. I.E.

A88-34813
STABILITY AND EQUILIBRIA OF DEFORMABLE SYSTEMS
ANTHONY M. BLOCH (Michigan, University, Ann Arbor) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1443, 1444. refs
(Contract NSF DMS-87-01574; AF-AFOSR-ISSA-87-0077)

The stability of the equilibrium states of a deformable body, consisting of a rigid body with attached flexible rod is considered. By the so-called Energy-Casimir method formal stability is proved for the nontrivial equilibrium with lowest angular velocity. I.E.

A88-34822
SPECTRAL ANALYSIS OF A CLASS OF INFINITE-DIMENSIONAL SYSTEMS
RENJENG SU (Colorado, University, Boulder) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1566, 1567. Research supported by the General Electric Co., Lockheed Corp., Martin Marietta Corp., AT&T, and NSF.

The problem is considered of large-scale systems that arise when a great number of basic structures, each of which can be appropriately modeled by a finite-dimensional dynamics, are connected, resulting in systems of very high dimensionality. Large-scale systems of this kind have a distinctive characteristic as compared to the dynamics of continuous media resulting from finite-element analysis. To illustrate this point, it is shown that serial connections of an infinite number of springs and masses give rise to dynamics with bounded spectral radii and the eigenvalues spread densely over the bounded region. I.E.

A88-34891

DESIGN OF A CONTROLLER FOR MECHANICAL SYSTEMS BY THE GENERALIZED ENERGY FUNCTION

SHINTARO ISHIJIMA (Tokyo Metropolitan Institute of Technology, Hino, Japan), HISATO KOBAYASHI (Hosei University, Koganei, Japan), and ETSUJIRO SHIMEMURA (Waseda University, Okubo, Japan) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 2186-2190. refs

A mechanical system with proportional dynamics is considered. Its dynamics are described by a matrix second-order differential equation; the coefficient matrices have properties such as symmetry and positivity. These properties are used to synthesize a better controller for such a system. The potential and kinetic energy of the system are considered. A concept called a generalized energy function is introduced and used as the basis for discussing observability and controllability. The problem of attitude control using position feedback is treated. I.E.

A88-34905

ON THE QUANTITATIVE CHARACTERIZATION OF APPROXIMATE DECENTRALIZED FIXED MODES USING TRANSMISSION ZEROS

A. F. VAZ and E. J. DAVISON (Toronto, University, Canada) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 2283-2288. refs
(Contract NSERC-A-4396)

The coordinate invariant distance between the open-loop eigenvalues and a set of transmission zeros is used to quantify the difficulty of shifting different modes in a system. It is shown that eigenvalues have an affinity for transmission zeros that lie nearby. Consequently, large controller gains are required to move eigenvalues away from such transmission zeros. This type of result is particularly useful for systems such as large flexible space structures, which have transmission zeros in the neighborhood of some system eigenvalues and manifest a great disparity in the mobility of their eigenvalues. Since not all systems have transmission zeros, a second measure of eigenvalue assignability that applies to all systems is introduced. This measure is based on the minimum singular value of a set of transmission zero matrices. The price of this generality is that the measure becomes coordinate-dependent. I.E.

A88-34914

MODELLING AND STABILIZATION OF FLEXIBLE SPACECRAFT UNDER THE INFLUENCE OF ORBITAL PERTURBATION

N. U. AHMED and SANG S. LIM (Ottawa, University, Canada) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 2331-2336. refs

The problem of modelling of large flexible spacecraft and their stabilization under the influence of orbital (radial) perturbation is considered. The dynamics of the flexible spacecraft is derived using Hamilton's principle. The equations of motion consist of a coupled system of ordinary differential equations and partial differential equations. The asymptotic stability of the system is proved using Lyapunov's approach. Simple feedback controls are suggested for the stabilization of the system. For illustration, numerical simulations are carried out. I.E.

A88-34916* Rensselaer Polytechnic Inst., Troy, NY.

MODEL REFERENCE CONTROL OF THE NASA SCOLE PROBLEM

HOWARD KAUFMAN and ABRAHAM MUSALEM (Rensselaer Polytechnic Institute, Troy, NY) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 2341-2343.
(Contract NAG1-515)

Model reference controllers have been developed and applied to the linearized Spacecraft Control Laboratory Experiment (SCOLE) roll beam mode equation. When a large- but finite-dimensional approximation to the partial differential equation is used, the resulting control will be finite-dimensional, but possibly not adequately representative for the actual distributed-parameter system. To date the theory for such model reference controllers has been developed; here it is applied to a 16th-order finite-dimensional representation of the flexible and rigid body modes of the SCOLE. Results of the analysis and some preliminary simulation studies are presented. I.E.

A88-34917

COMPUTING THE TRANSMISSION ZEROS OF LARGE SPACE STRUCTURES

TREVOR WILLIAMS (NASA, Langley Research Center, Hampton, VA) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 2344, 2345. SERC-supported research. refs

The transmission zeros of a large space structure can be computed by the general-purpose algorithm of A. Emami-Naeini and P. Van Dooren (1982). However, careful use of the special form of the equations of motion of structural dynamics leads to a new method that is about twice as fast as theirs when applied to a damped structure, and at least 60 times as fast for an undamped one. I.E.

A88-35102

GROUND-TEST OF SPACECRAFT CONTROL AND DYNAMICS

SHERMAN M. SELTZER and MICHAEL A. POPE (Control Dynamics Co., Huntsville, AL) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 763-785.
(AAS PAPER 86-267)

The dynamic behavior and closed-loop control of large space structures are being demonstrated and verified at NASA-Marshall in a new facility that consists of a control torque command-furnishing payload-mounting system to which test articles are connected. The mounting system is in turn attached to a base-excitation system that can simulate the disturbances that are most likely to occur with Space Shuttle Orbiter and Department of Defense payloads. A control computer contains the calibration software, reference system, alignment procedures, telemetry software, and control algorithms. The facility can be extensively modified to emulate various spacecraft configurations. O.C.

A88-35116* Martin Marietta Corp., Denver, CO.

MEMBER VIBRATION EFFECTS ON LSS BEHAVIOR

CHARLES W. WHITE (Martin Marietta Corp., Denver, CO) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1035-1049. refs
(Contract NAS1-7551)
(AAS PAPER 86-396)

This paper evaluates the sensitivity of modal characteristics of large deployable lattice-type space structures to joint boundary conditions. The evaluation of joint rotational boundary conditions is accomplished by a review of modal strain energy among elements of the analytic dynamic model. This review shows that space structure designs having no bending energy in lattice members in the low frequency range are insensitive to joint rotational boundary conditions in that frequency range. Evaluation of joint translation boundary conditions is accomplished by the 'modal freeplay method' which is described in this paper. The modal freeplay method relates modal frequency to joint translational freeplay and to amplitude of applied forces. Author

A88-35117

DISTRIBUTED AND CONCURRENT COMPUTATION FOR SPACE STRUCTURES

JOHN E. HERSHEY, ROBERT F. KUBICHEK, and JAMES E. SCHROEDER (BDM Corp., Boulder, CO) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1051-1055.
(AAS PAPER 86-397)

An evaluation is made of the development status and prospects of distributed/concurrent real-time computation methods in the control of large space structures, with attention to the subtle interplay between hardware, algorithm, and computer architecture design factors. Current efforts are noted to be developing in distinct, microparallelization and macroparallelization directions. It appears doubtful that any single processor will be sufficient to handle the real-time computational loads associated with such structures. O.C.

A88-35541

INTERACTIVE STRUCTURAL AND CONTROLLER SYNTHESIS FOR LARGE SPACECRAFT

S. C. MCINTOSH, JR. (McIntosh Structural Dynamics, Inc., Palo Alto, CA) and M. A. FLOYD (Integrated Systems, Inc., Palo Alto, CA) IN: Recent trends in aeroelasticity, structures, and structural dynamics; Proceedings of the R. L. Bisplinghoff Memorial Symposium, Gainesville, FL, Feb. 6, 7, 1986. Gainesville, FL, University Presses of Florida, 1987, p. 283-297. refs
(Contract F49620-84-C-0025)

A technique is developed for least-weight optimal design of a tubular-truss space structure, subject to constraints on its natural frequencies and its open-loop disturbance-rejection properties. The disturbance-rejection properties of the structure are measured by disturbance-to-regulated-variable grammians. It is shown how this technique can be embedded in a model-reduction scheme based on internal balancing. The procedure is applied to to a simple 'dumbbell' model and CSDL Model No. 1. Author

A88-35543

DYNAMIC RESPONSES OF ORTHOTROPIC PLATES UNDER MOVING MASSES

O. P. AGRAWAL (Southern Illinois University, Carbondale, IL) and SUNIL SAIGAL (Worcester Polytechnic Institute, MA) IN: Recent trends in aeroelasticity, structures, and structural dynamics; Proceedings of the R. L. Bisplinghoff Memorial Symposium, Gainesville, FL, Feb. 6, 7, 1986. Gainesville, FL, University Presses of Florida, 1987, p. 313-333. refs

The problem considered is that of heavy masses moving on lightweight rectangular plates of orthotropic materials, slated for use in space structures. The dynamic equation of motion for orthotropic plates which contains singularities in both space and time variables is first presented. The response is expressed as a summation of double series of eigenfunctions. The equation of motion is transformed into an integro-differential equation for modal amplitudes using the Green's function. The Green's function is chosen to satisfy the initial conditions, the boundary conditions, and the transient conditions due to the moving masses. The solution series exhibits a good convergence. The effect of orthotropicity on natural frequencies and dynamic responses is demonstrated. Author

A88-36311* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

REAL-TIME MODEL-BASED VISION SYSTEM FOR OBJECT ACQUISITION AND TRACKING

BRIAN WILCOX, DONALD B. GENNERY, BRUCE BON, and TODD LITWIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Optical and digital pattern recognition; Proceedings of the Meeting, Los Angeles, CA, Jan. 13-15, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 276-281. refs

A machine vision system is described which is designed to acquire and track polyhedral objects moving and rotating in space by means of two or more cameras, programmable image-processing hardware, and a general-purpose computer for high-level functions. The image-processing hardware is capable of performing a large variety of operations on images and on image-like arrays of data. Acquisition utilizes image locations and velocities of the features extracted by the image-processing hardware to determine the three-dimensional position, orientation, velocity, and angular velocity of the object. Tracking correlates edges detected in the current image with edge locations predicted from an internal model of the object and its motion, continually updating velocity information to predict where edges should appear in future frames. With some 10 frames processed per second, real-time tracking is possible. V.L.

A88-36718#

KALMAN FILTERING FOR SECOND-ORDER MODELS

HAMID R. HASHEMIPOUR (Tau Corp., Los Gatos, CA) and ALAN J. LAUB (California, University, Santa Barbara) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Mar.-Apr. 1988, p. 181-186. Research supported by Lawrence Livermore National Laboratory. refs
(Contract N00014-85-K-0553; NSF ECS-84-06152)

'Second-order model' Kalman filter algorithms are developed for systems describable by either linear, second-order matrix differential equations or difference equations. The results obtainable differ from those of standard Kalman filtering for state-space models not only in that error covariances are required in the equations; also, certain error cross-covariances emerge. Proper implementation should be conducted in factorized form. O.C.

A88-38389#

DYNAMICS OF VISCOELASTIC STRUCTURES

K. J. BUHARIWALA and J. S. HANSEN (Toronto, University, Canada) AIAA Journal (ISSN 0001-1452), vol. 26, Feb. 1988, p. 220-227. refs

A general method is presented for model material damping in dynamical systems. The work is primarily concerned with a dissipation model based on viscoelastic assumptions. Motion equations are formulated in operator form for a structure constructed from an anisotropic, viscoelastic material. The mass, damping, and stiffness operators are developed consistently in the formulation. Basic operator properties are discussed, and orthonormality conditions are derived for the viscoelastic system. Modal identities are derived for a constrained viscoelastic structure. These identities provide useful criteria in order reduction of finite-element models. An example of a viscoelastic beam in pure flexure is illustrated. Author

A88-38390#

EXPERIMENTAL STUDY OF TRANSIENT WAVES IN A PLANE GRID STRUCTURE

WILLIAM L. HALLAUER, JR. and DINESH J. TRIVEDI (Virginia Polytechnic Institute and State University, Blacksburg) (Structures, Structural Dynamics, and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B, p. 888-899) AIAA Journal (ISSN 0001-1452), vol. 26, Feb. 1988, p. 228-234. Previously cited in issue 14, p. 2174, Accession no. A87-33741. refs
(Contract F49620-85-C-0024; NSF CME-80-14059)

A88-39724

DISTRIBUTED SENSORS AND ACTUATORS FOR VIBRATION CONTROL IN ELASTIC COMPONENTS

J. E. HUBBARD, JR. (Charles Stark Draper Laboratory, Inc.; MIT, Cambridge, MA) IN: NOISE-CON 87; Proceedings of the National

Conference on Noise Control Engineering, State College, PA, June 8-10, 1987. Poughkeepsie, NY, Noise Control Foundation, 1987, p. 407-412.

The paper presents data pertaining to the design and implementation of distributed sensing and actuation for one-dimensional structural components which may be used in the design of large space structures for active vibration control. The results apply to an active damper developed at the Massachusetts Institute of Technology which involves the use of polyvinylidene. The system made up of a sensing film, a beam structure, and an actuation film represents an autonomous structure which may be combined with closed loop control strategies to yield 'smart' structural members in more complex systems. K.K.

A88-40261

INSTRUMENTATION FOR MODAL TESTING OF LARGE SPACE STRUCTURES

DOUGLAS A. HENDERSON and WAYNE YUEN (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: 1987 SEM Spring Conference on Experimental Mechanics, Houston, TX, June 14-19, 1987, Proceedings. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 122-127. refs

Instrumentation and modal parameter survey requirements for two 12-m truss beams are described, and problems associated with the ground testing of large space structures are identified. In particular, attention is given to transducer selection and data measurement requirements. Piezoelectric, piezoresistive, and LED sensors are found to meet frequency, dynamic range, and practical usage requirements. Future transducer requirements are reviewed, emphasizing the requirements for low mass velocity sensors, greater proximity probe gap sizes, and improved fiber optics methods. V.L.

A88-40269* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A COMPARATIVE OVERVIEW OF MODAL TESTING AND SYSTEM IDENTIFICATION FOR CONTROL OF STRUCTURES

JER-NAN JUANG and RICHARD S. PAPPA (NASA, Langley Research Center, Hampton, VA) IN: 1987 SEM Spring Conference on Experimental Mechanics, Houston, TX, June 14-19, 1987, Proceedings. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 250-259. refs

This paper presents a comparative overview of the disciplines of modal testing used in structural engineering and system identification used in control theory. A list of representative references from both areas is given and the basic methods are briefly described. Recent progress on the interaction of modal testing and control disciplines is discussed. It is concluded that combined efforts of researchers in both disciplines are required for unification of modal testing and system identification methods for control of flexible structures. Author

A88-40271

AN ITERATIVE APPROACH TO PARAMETER IDENTIFICATION IN STRUCTURES

L. MEIROVITCH and M. A. NORRIS (Virginia Polytechnic Institute and State University, Blacksburg) IN: 1987 SEM Spring Conference on Experimental Mechanics, Houston, TX, June 14-19, 1987, Proceedings. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 268-273. refs

This paper presents a method for identifying parameters in a truss structure by representing it as a nonuniform continuous beam. The parameters are expanded in terms of linear combinations of known functions multiplied by unknown coefficients. The identification scheme is concerned with the determination of these coefficients. The coefficients are obtained iteratively in a process similar to Gauss' least squares differential correction algorithm. A numerical example involving a tapered truss is presented. Author

A88-40489

ROBUST CONTROL OF FLEXIBLE STRUCTURES - A CASE STUDY

J. BONTSEMA, R. F. CURTAIN (Groningen, Rijksuniversiteit, Netherlands), and J. M. SCHUMACHER (Centrum voor Wiskunde en Informatica, Amsterdam, Netherlands) Automatica (ISSN 0005-1098), vol. 24, March 1988, p. 177-186. Research supported by the Stichting voor de Technische Wetenschappen. refs

A comparison is made between three partial differential equation models for a flexible beam with different types of damping and varying parameter values. Robust controllers can be designed to stabilize all linear systems whose transfer functions lie within a ball in the L-infinity norm. Given a nominal model for the flexible beam the sets of models that can be stabilized by the same finite-dimensional robust controller are calculated. Author

A88-40773*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ANALYTIC REDUNDANCY MANAGEMENT FOR SYSTEMS WITH APPRECIABLE STRUCTURAL DYNAMICS

RAYMOND C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA) International Association for Mathematics and Computers in Simulation, World Congress on Scientific Computation, 12th, Paris, France, July 18-22, 1988, Paper. 4 p. refs

This paper deals with analytic redundancy management of systems that have appreciable structural dynamics and require active control. The class of systems considered is large, lightweight spacecraft that have large numbers of distributed sensors and actuators. Both preliminary design and on-line operations are studied. For the preliminary design we deal with the placement of the sensor and actuator components on a highly flexible spacecraft. For on-line operation an analytic redundancy management system based on examination of the residuals of a Kalman filter is considered. A large, flexible grid made of overlapping aluminum bars is used to experimentally evaluate this analytic redundancy management system. Results of the experimental evaluation are included in the paper. Author

A88-42574

STRUCTURAL VIBRATION OF SPACE POWER STATION SYSTEMS

M. J. CROCKER, P. K. RAJU, E. CHRISTENSEN, N. H. MADSEN, E. GUINDON (Auburn University, AL) et al. IN: Space structures, power, and power conditioning; Proceedings of the Meeting, Los Angeles, CA, Jan. 11-13, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 205-224. Research supported by Auburn University and SDIO. refs (Contract DNA001-85-C-0183)

A new approach to the control of active vibration in large flexible structures based on wave cancellation techniques is reported. A finite element model of the vibratory response of large flexible spacecraft truss structures to systems of applied forces representing machinery forces and maneuvers is developed. Predictions regarding the pointing accuracy and tip displacement of such structures to the assumed force inputs are presented. The optimization of the structures to minimize dynamic response is addressed, and interfacial damping in composite structures is modeled and subjected to finite element analysis. C.D.

A88-42576

MINIMUM-TIME CONTROL OF LARGE SPACE STRUCTURES

ROBERT L. KOSUT, ANTONIO M. PASCOAL (Integrated Systems, Inc., Santa Clara, CA), MICHAEL L. WORKMAN (IBM, San Jose, CA), and GENE F. FRANKLIN (Stanford University, CA) IN: Space structures, power, and power conditioning; Proceedings of the Meeting, Los Angeles, CA, Jan. 11-13, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 230-241. SDIO-sponsored research. refs

An Extended Proximate Time-Optimal Servomechanism (XPTOS) is developed for the control of a flexible structure with a single structural mode. The resulting control system is closed-loop, and embodies in its structure the characteristics of a time-optimal control law and the fine tracking properties of a properly tuned linear regulator. Simulation results demonstrate the performance of the XPTOS, and its robustness in the face of uncertain plant parameters. Author

A88-42577

EXPERIMENTAL INVESTIGATIONS IN ACTIVE VIBRATION CONTROL FOR APPLICATION TO LARGE SPACE SYSTEMS

DAVID C. HYLAND (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: Space structures, power, and power conditioning; Proceedings of the Meeting, Los Angeles, CA, Jan. 11-13, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 242-253.

Vibration control experiments were designed on the basis of a recent survey of large space system concepts and the identified characteristics of ground-based experiments needed to demonstrate capability for future systems. The experiments involve a progression of structural configurations ranging from relatively simple one- and two-dimensional systems to a large-aperture multisegment optical structure. The following experiments are described in detail: (1) the Pendulum Experiment, (2) the Plate Experiment, and (3) the Multihex Prototype Experiment. K.K.

A88-42582

DYNAMICS AND CONTROL OF LARGE SPACE PLATFORMS AND SMALL EXPERIMENTAL PAYLOADS

J. E. COCHRAN, JR., N. G. FITZ-COY, K. KUMAR, and T. S. NO (Auburn University, AL) IN: Space structures, power, and power conditioning; Proceedings of the Meeting, Los Angeles, CA, Jan. 11-13, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 282-296. refs

(Contract DNA001-85-C-0183)

A capability developed to study the dynamics and control of space platforms in connection with the generation, conversion and utilization of power in space is described. It is based on the use of both rigid and flexible models of platform configurations which may be rather arbitrary. The principal part of the capability is a digital simulation code which uses the results of analyses of finite element models of platforms to account for their flexibilities. By using the code, the general motion of fairly complex configurations including rotating components may be simulated. The control of gross attitude motion is accomplished via a minimum impulse limit cycle controller. Examples of gross attitude motion and 'fine' motion due to flexibility are presented. Also, to illustrate the versatility of the code, results are presented of simulations of the motion of a small, suborbital, experimental payload which has deployable booms. Another aspect of the overall capability is spotlighted through an example of the attitude dynamics of the experiment carrying suborbital vehicle during boom deployment. Author

A88-43030#

NEW APPROACH TO THE ANALYSIS AND CONTROL OF LARGE SPACE STRUCTURES

G. ADOMIAN (General Analytics Corp., Roswell, GA) AIAA Journal (ISSN 0001-1452), vol. 26, March 1988, p. 377-380.

(Contract F49620-87-C-0098)

Orbiting space stations' thermal and structural analysis difficulties arise from the severe requirements of large size, low weight, high stiffness, and minimum mechanical and thermal distortion (millimetric tolerances). Attention is presently given to a decomposition method which solves the systems of multidimensional nonlinear stochastic partial differential equations (or ordinary differential equations, or integrodifferential, or delay differential equations) in space and time, without linearization, discretization, or perturbation. O.C.

A88-43203#

INPUT SELECTION FOR A SECOND-ORDER MASS PROPERTY ESTIMATOR

ROBERT F. RICHFIELD (U.S. Army, Redstone Arsenal, AL), BRUCE K. WALKER (Cincinnati, University, OH), and EDWARD V. BERGMANN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 57-67) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 207-212. Previously cited in issue 23, p. 3425, Accession no. A86-47409. refs

A88-43206*# State Univ. of New York, Buffalo.

MICROPROCESSOR CONTROLLED FORCE ACTUATOR

D. C. ZIMMERMAN, D. J. INMAN (New York, State University, Buffalo), and G. C. HORNER (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1, p. 243-251) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 230-236. Previously cited in issue 18, p. 2617, Accession no. A86-38827. refs

(Contract NGT-33-183-801; NSF MEA-83-51807; AF-AFOSR-85-0220)

A88-43211*# Illinois Univ., Urbana.

VARIABLE-STRUCTURE CONTROL OF SPACECRAFT ATTITUDE MANEUVERS

THOMAS A. W. DWYER, III and HEBERTT SIRA-RAMIREZ (Illinois, University, Urbana) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 262-270. refs

(Contract NAG1-436; NSF ECS-85-16445; N00014-84-C-0149)

A variable-structure control approach is presented for multiaxial spacecraft attitude maneuvers. Nonlinear sliding surfaces are proposed that result in asymptotically stable, ideal linear decoupled sliding motions of Cayley-Rodrigues attitude parameters, as well as of angular velocities. The resulting control laws are interpreted as more easily implemented and more robust versions of those previously obtained by feedback linearization. Author

A88-43212#

ACTIVE VIBRATION CONTROL SYNTHESIS FOR THE CONTROL OF FLEXIBLE STRUCTURES MAST FLIGHT SYSTEM

BONG WIE (Texas, University, Austin) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 271-277. Previously cited in issue 22, p. 3549, Accession no. A87-50443. refs

A88-43215#

EVALUATION OF IMAGE STABILITY OF A PRECISION POINTING SPACECRAFT

HARI B. HABLANI (Rockwell International Corp., Seal Beach, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 283-286.

A discrete Fourier transform presentation is given for a 'clutter leakage metrics' device, which is a Fourier-integral form available in the electrooptics literature for the evaluation of image stability in precision-pointing telescopes. The metrics encompass the Fourier spectrum of the pointing error, an integration interval, and a differencing operation; these are presently demonstrated for the case of a telescope whose image stability during landmark tracking is disturbed by a neighboring solar array. O.C.

A88-44670#

AUTONOMOUS FLIGHT CONTROL FOR LOW THRUST ORBITAL TRANSFER VEHICLES

RONALD E. OGLEVIE, THOMAS R. EGAN (Irvine Technology Group, Inc., CA), and JAY P. PENN (Aerospace Corp., El Segundo, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p.

(Contract F04701-87-C-0078)

(AIAA PAPER 88-2838)

USAF's Systems Command is evaluating the use of an electric-propulsion OTV (EOTV) for the reduced-cost replenishment of GPS and geosynchronous spacecraft. The EOTV must be capable of highly autonomous navigation, docking, and fault-management operations; it will be so optimally guided as to minimize transfer time, irrespective of the effects of solar occultation and earth oblateness. GPS navigation, cellestially-aided inertial attitude determination, and scanning lidar for docking, will be incorporated in the EOTV. Software requirements have been determined to lie within the capacity of existing flight-qualified computers. O.C.

A88-45227* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

OPTIMAL EXPERIMENT DESIGN FOR IDENTIFICATION OF LARGE SPACE STRUCTURES

D. S. BAYARD, F. Y. HADAEGH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and D. R. MELDRUM (Stanford University, CA) Automatica (ISSN 0005-1098), vol. 24, May 1988, p. 357-364. refs

The optimal experiment design for on-orbit identification of modal frequency and damping parameters in large flexible space structures is discussed. The main result is a separation principle for D-optimal design which states that under certain conditions the sensor placement problem is decoupled from the input design problem. This decoupling effect significantly simplifies the overall optimal experiment design determination for large MIMO structural systems with many unknown modal parameters. The error from using the uncoupled design is estimated in terms of the inherent damping of the structure. A numerical example is given, demonstrating the usefulness of the simplified criteria in determining optimal designs for on-orbit Space Station identification experiments. Author

A88-45467

DETERMINATION OF THE MOTION OF THE SALYUT 6 AND 7 ORBITAL STATIONS WITH RESPECT TO THE MASS CENTER IN THE SLOW SPIN MODE ON THE BASIS OF MEASUREMENT DATA [OPREDELENIE DVIZHENIIA ORBITAL'NYKH STANTSII 'SALIUT-6' I 'SALIUT-7' OTNOSITEL'NO TSENTRA MASS V REZHIME MEDLENNOI ZAKRUTKI PO DANNYM IZMERENII]

V. A. SARYCHEV, M. IU. BELIAEV, S. P. KUZ'MIN, V. V. SAZONOV, and T. N. TIAN Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 26, May-June 1988, p. 390-405. In Russian. refs

A method is proposed for determining the rotational motion of Salyut 6 and 7 in the slow spin mode (with an angular velocity of not greater than about 0.2 deg/s) according to the readings of onboard sensors which measure the geomagnetic frield strength vector and the sun position vector. Particular attention is given to the motion of Salyut-7 with respect to the mass center over long periods of time. It is shown that, several days after the commencement of uncontrolled motion with a small initial angular velocity, the spacecraft is captured into a uniaxial gravity-gradient regime, in which its longitudinal axis undergoes stable oscillations with respect to the local vertical with an amplitude of about 40 deg. B.J.

A88-45712* Georgia Inst. of Tech., Atlanta.

SINGULAR PERTURBATION ANALYSIS OF THE ATMOSPHERIC ORBITAL PLANE CHANGE PROBLEM

A. J. CALISE (Georgia Institute of Technology, Atlanta) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 36, Jan.-June 1988, p. 35-43. refs
(Contract NAG1-660)

A three-state model is presented for the aeroassisted orbital plane change problem. A further model order reduction to a single state model is examined using singular perturbation theory. The optimal solution for this single state model compares favorably with the exact numerical solution using a four-state model; however, a separate boundary layer solution is required to satisfy the terminal constraint on altitude. This, in general, involves the solution of a two-point boundary value problem, but for a two-state model. An approximation is introduced to obtain an analytical control solution for lift and bank angle. Included are numerical simulation results of a guidance law derived from this analysis, along with comparison to earlier work by other researchers. Author

A88-46041* Brown Univ., Providence, RI.

THE IDENTIFICATION OF A DISTRIBUTED PARAMETER MODEL FOR A FLEXIBLE STRUCTURE

H. T. BANKS (Brown University, Providence, RI), S. S. GATES (Charles Stark Draper Laboratory, Inc., Cambridge, MA), I. G. ROSEN, and Y. WANG (Southern California, University, Los Angeles, CA) SIAM Journal on Control and Optimization (ISSN 0363-0129), vol. 26, July 1988, p. 743-762. Previously announced in STAR as N87-19760. refs
(Contract NSF MCS-85-04316; AF-AFOSR-84-0398; AF-AFOSR-84-0393; NAG1-517; NAS1-17070; NAS1-18107)

A computational method is developed for the estimation of parameters in a distributed model for a flexible structure. The structure we consider (part of the RPL experiment) consists of a cantilevered beam with a thruster and linear accelerometer at the free end. The thruster is fed by a pressurized hose whose horizontal motion effects the transverse vibration of the beam. The Euler-Bernoulli theory is used to model the vibration of the beam and treat the hose thruster assembly as a lumped or point mass dashpot spring system at the tip. Measurements of linear acceleration at the tip are used to estimate the hose parameters (mass, stiffness, damping) and a Voigt-Kelvin viscoelastic structural damping parameter for the beam using a least squares fit to the data. Spline based approximations are considered to the hybrid (coupled ordinary and partial differential equations) systems; theoretical convergence results and numerical studies with both simulation and actual experimental data obtained from the structure are presented and discussed. Author

A88-46401

LARGE SPACE STRUCTURES: DYNAMICS AND CONTROL

SATYA N. ATLURI, ED. (Georgia Institute of Technology, Atlanta) and ANTHONY K. AMOS, ED. (USAF, Office of Scientific Research, Bolling AFB, Washington, DC) Berlin and New York, Springer-Verlag, 1988, 373 p. For individual items see A88-46402 to A88-46414.

Recent advances in the dynamical design and control theory of large space structures (LSSs) are examined in chapters contributed by leading experts. Topics addressed include continuum modeling of large lattice structures, computational aspects of nonlinearities in the dynamics and control of LSSs, modal cost analysis for simple continua, the transient dynamics of flexible LSSs, control-LSS interaction analysis, the dynamical response of an LSS to pulse excitation, and modeling techniques for open- and closed-loop LSS dynamics. Consideration is given to dynamic friction, control of distributed structures, the acoustic limit of structural-dynamic control, active control for vibration damping, a unified theory of reduced-order robust control design, adaptive control of LSSs, and unified optimization of structures and controllers T.K.

A88-46403

NONLINEARITIES IN THE DYNAMICS AND CONTROL OF SPACE STRUCTURES - SOME ISSUES FOR COMPUTATIONAL MECHANICS

S. N. ATLURI and M. IURA (Georgia Institute of Technology, Atlanta) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 35-70. USAF-SDIO-supported research. refs

Semidiscrete computational methods for the dynamical analysis of large space structures (LSSs) and the design of passive or active LSS controllers are described and demonstrated. Strategies for reduced-order structural-dynamic modeling of beam and shell LSSs undergoing large deformation are developed analytically, representing the LSSs as equivalent elastic continua, and applied to truss-and-frame lattice-type LSSs. Particular attention is given to sample problems involving a 12-bay space truss subjected to axial loads, a framed dome loaded at the crown point, and a beam-column lined with piezoelectric material. Extensive diagrams, graphs, and tables of numerical data are provided. T.K.

A88-46405

ON THE TRANSIENT DYNAMICS OF FLEXIBLE ORBITING STRUCTURES

V. J. MODI and A. M. IBRAHIM (British Columbia, University, Vancouver, Canada) IN: Large space structures: Dynamics and

control. Berlin and New York, Springer-Verlag, 1988, p. 95-114. refs
(Contract NSERC-G-1547)

Complex interactions between deployment, attitude dynamics and flexural rigidity are reviewed using a rather general formulation applicable to a large class of space platforms with flexible, extensible members. The governing nonlinear, nonautonomous and coupled hybrid set of equations are extremely difficult to solve even with the help of a computer, not to mention the cost involved. Effectiveness of the versatile formulation is demonstrated through its application to several dynamical situations of contemporary interest involving beam type appendages. Both transient as well as postdeployment phases are considered. Results suggest significant influence of flexibility, inertia, deployment time history and orbital parameters on the system stability. The presence of free molecular and solar radiation induced environmental forces may further accentuate this tendency. The information has relevance to the design of control systems for the next generation of communications satellites with large solar panels; the Orbiter-based experiments such as SAFE, COFS, NASA/CNR tethered subsatellite system, etc.; as well as constructional and operational phases of the proposed space station. Author

A88-46406* Colorado Univ., Boulder.

COMPUTATIONAL ISSUES IN CONTROL-STRUCTURE INTERACTION ANALYSIS

K. C. PARK (Colorado, University, Boulder) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 115-131. refs
(Contract F49620-87-C-0074; NAG1-756)

This paper surveys computational issues for large-scale simulation of dynamics and controls of space structures, which involve structural elements that are capable of large combined rigid and flexible motions, accurate and efficient treatment of constraints, robust integration of both translational and large rotational motions in the equations of motion, modular interface with active control synthesis packages, and a capability from wave motions to slowly varying transient responses. A particular feature of the present survey is a partitioned solution (or divide-and-conquer) procedure that can handle the numerical solution of multidisciplinary simulation problems by relying on individual modular solution packages that treat each aspect of simulation requirements. Author

A88-46408

CONTROL OF DISTRIBUTED STRUCTURES

LEONARD MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 195-212. refs

The modal or direct-feedback control of distributed structures is considered theoretically, summarizing the results of the author's recent investigations (Meirovitch, 1980, 1987, and 1988; Meirovitch and Baruh, 1983 and 1985; Meirovitch and Silverberg, 1983). The derivations of the equation of motion for a distributed structure and the modal equations are outlined; mode controllability and observability are defined; the closed-loop modal equations are obtained; and particular attention is given to independent modal-space control, pole allocation, optimal control, control by point actuators, control spillover, observation spillover, feedback control, and proportional damping. The optimal choice of gain is shown to be a critical problem in both modal and feedback controls. T.K.

A88-46409

THE ACOUSTIC LIMIT OF CONTROL OF STRUCTURAL DYNAMICS

A. H. VON FLOTOW (MIT, Cambridge, MA) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 213-237. Research supported by the Alexander von Humboldt-Stiftung, NSERC, USAF, and DFVLR. refs

This paper investigates the acoustic limit of active control of structural dynamics; the limit as the control bandwidth includes a very large number of natural modes of the structure. The point is made that in this limit modal analysis cannot provide reasonably accurate models of the structural dynamics, and that control design with respect to modal models is then of questionable value. Alternative modeling approaches are reviewed. A particular wave propagation formalism, applicable to modeling the acoustic response of networks of slender structural members, is described in some detail. Control options designed with reference to this formalism are reviewed, and speculations as to future developments of such control are offered. Author

A88-46410

ACTIVE CONTROL FOR VIBRATION DAMPING

P. J. LYNCH (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 239-261. refs

Active control laws are developed for an LSS-type structure to damp vibrations. High frequency modeling uncertainties lead to the necessity for a robust control design. The Linear Quadratic Gaussian with Loop Transfer Recovery (LQG/LTR) control design technique is a particular robust design technique selected for use in designing a damping control system. A summary of LQG/LTR is given and numerical example using a two bay truss is presented. Author

A88-46411

OPTIMAL PROJECTION FOR UNCERTAIN SYSTEMS (OPUS) - A UNIFIED THEORY OF REDUCED-ORDER, ROBUST CONTROL DESIGN

DENNIS S. BERNSTEIN and DAVID C. HYLAND (Harris Corp., Government Aerospace Systems Div., Melbourne, Florida) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 263-302. refs
(Contract F49620-86-C-0002; F49620-86-C-0038)

Recent advances in the numerical solution of active-vibration-control problems for large flexible structures are examined in an analytical review, with a focus on the optimal-projection algorithm OPUS (Bernstein, 1986). The fundamental principles of vibration suppression are recalled; the linear-quadratic-Gaussian (LQG) design technique is described; and the operation of OPUS is characterized in detail and illustrated with extensive diagrams and flow charts. In OPUS, the LQG approach is generalized in two different ways to permit simultaneous development of low-order and robust controllers, employing the efficient homotropy algorithm of Richter (1987) in the solution of pairs of Riccati and Liapunov equations coupled by optimal projection and uncertainty terms, respectively. Such an approach is shown to account for all major tradeoffs in the design of practical controllers for large space structures. T.K.

A88-46412

ADAPTIVE CONTROL OF LARGE SPACE STRUCTURES - UNCERTAINTY ESTIMATION AND ROBUST CONTROL CALIBRATION

ROBERT L. KOSUT (Integrated Systems, Inc., Santa Clara, CA) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 303-321. refs
(Contract F49620-85-C-0094)

An approach is presented to the problem of designing a robust control using on-line measurements. The idea is to use standard methods of parametric system identification to obtain a nominal estimate of the plant transfer function. Nonparametric spectral methods are then used to obtain a frequency domain expression for model uncertainty. If the model uncertainty exceeds a specified frequency bound, which has been predetermined from the nominal model and the performance criteria, then data filters used in the system identification are modified and the procedure is repeated. An analysis is presented which establishes conditions under which the procedure will actually converge to a satisfactory robust design. An example is provided which illustrates the method and supporting analysis. Author

A88-46413

UNIFIED OPTIMIZATION OF STRUCTURES AND CONTROLLERS

J. L. JUNKINS and D. W. REW (Texas A & M University, College Station) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 323-353. refs
(Contract F49620-86-K-0014)

The theoretical basis and performance of methods for the solution of high-dimensional structural control problems are examined, reviewing the results of recent investigations. The emphasis is on robust eigenstructure-assignment methods and optimization methods in which both the controller and selected structural parameters are readjusted to improve robustness. Families of designs displaying the inherent tradeoffs between robustness, small control errors, and small controller inputs are generated, and the use of homotopy methods is shown to improve the convergence of iterative numerical procedures. Diagrams, graphs, and tables of numerical data are provided. T.K.

A88-46712#

SOME APPROXIMATIONS FOR THE DYNAMICS OF SPACECRAFT TETHERS

A. H. VON FLOTOW (MIT, Cambridge, MA) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A, p. 314-321) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, July-Aug. 1988, p. 357-364. USAF-sponsored research. Previously cited in issue 14, p. 2116, Accession no. A87-33687. refs

A88-46717# Beijing Inst. of Control Engineering (China).

DYNAMICS AND CONTROL OF A SPACE PLATFORM WITH A TETHERED SUBSATELLITE

RUYING FAN (Beijing Institute of Control Engineering, People's Republic of China) and PETER M. BAINUM (Howard University, Washington, DC) (NASA, AIAA, and PSN, International Conference on Tethers in Space, Arlington, VA, Sept. 17-19, 1986) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, July-Aug. 1988, p. 377-381. Abridged. Research supported by the Ministry of Astronautics of the People's Republic of China, Howard University, and NASA. Previously cited in issue 03, p. 309, Accession no. A87-14074.

A88-47462#

GAME THEORY APPROACH FOR THE INTEGRATED DESIGN OF STRUCTURES AND CONTROLS

S. S. RAO (Purdue University, West Lafayette, IN), V. B. VENKAYYA, and N. S. KHOT (USAF, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 26, April 1988, p. 463-469. USAF-supported research. refs

The problem of design of actively controlled structures subject to constraints on the damping parameters of the closed-loop system is formulated as a multiobjective optimization problem. The structural weight and the controlled system energy are considered as objective functions for minimization with cross-sectional areas of members as design varibles. A computational procedure is developed for solving the multiobjective optimization problem using cooperative game theory. The feasibility of the procedure is demonstrated through the design of two truss structures. Author

A88-47907

ASTRODYNAMICS PROBLEMS OF THE SPACE STATION

J.-P. MAREC, P. BAINUM, J. V. BREAKWELL, C. MARCHAL, V. J. MODI (IAF, Paris, France) et al. Acta Astronautica (ISSN 0094-5765), vol. 17, May 1988, p. 491-494.

The preliminary views of the IAF Astrodynamics Committee on the astrodynamics problems related to the Space Station concept are presented. A brief description of the Space Station system and of its original features is given. Some astrodynamics problems are considered in more detail, concerning attitude motion (modeling, attitude determination and control, and tether applications) and orbital motion (transfer, docking, navigation/positioning/guidance, collision hazards, and data links). Author

A88-48080

MATHEMATICAL MODELING OF THE DYNAMICS OF A SPACECRAFT WITH ELASTIC COMPONENTS [MATEMATICHESKOE MODELIROVANIE DINAMIKI KOSMICHESKOGO APPARATA S UPRUGIMI ELEMENTAMI]

P. A. BELONOZHKO and S. V. TARASOV Kosmicheskaia Nauka i Tekhnika (ISSN 0321-4508), no. 2, 1987, p. 18-22. In Russian. refs

An analysis is made of the dynamics of a spacecraft which is modeled as a kinematic chain of bodies containing zero-mass elastic components. The modeling procedure takes into account elastic deformations of the components using algebraic relationships which supplement the differential equations describing a system with rigid components. B.J.

A88-48082

INVESTIGATION OF THE DYNAMICS OF A SYSTEM OF BODIES CONTAINING EXTENDED ELASTIC COMPONENTS IN A CENTRAL FORCE FIELD [K ISSLEDOVANIIU DINAMIKI SISTEM TEL, SODERZHASHCHIKH PROTIAZHENNYE UPRUGIE ELEMENTY, V TSENTRAL'NOM POLE SIL]

S. S. CHERNIAVSKAIA Kosmicheskaia Nauka i Tekhnika (ISSN 0321-4508), no. 2, 1987, p. 28-31. In Russian.

A mathematical model is developed for a free system consisting of absolutely rigid and elastic extended bodies in a central gravitational field. The model describes the three-dimensional motion of the system in the case of elastic deformations of its components. The solution is represented in the form of an eigenfunction series. As an example, attention is given to the determination of the amplitudes of the elastic vibrations of a plane rectilinear chain of bodies connected by elastic extended rods. B.J.

A88-48194#

STRESS CONCENTRATION AROUND A PAIR OF CIRCULAR HOLES IN A HYDROSTATICALLY STRESSED ELASTIC SHEET

G. M. T. D'ELEUTERIO (Toronto, University, Downsview, Canada) ASME, Transactions, Journal of Applied Mechanics (ISSN 0021-8936), vol. 55, June 1988, p. 488, 489. NSERC-supported research. refs

Kienzler and Duan's (1987) simple, compact expression for the hoop stresses around a circular hole in an infinite sheet that is subjected to a given loading can be used to find approximate expressions for hoop stresses in a sheet that contains a pair of holes. Accurate results are thereby obtainable with virtually no calculations, as is presently illustrated for the subjection of the sheet to a hydrostatic tension at infinity. O.C.

A88-48957#

SPACE-BASED SYSTEM DISTURBANCES CAUSED BY ON-BOARD FLUID MOTION DURING SYSTEM MANEUVERS

J. NAVICKAS (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1558-1562. refs
(AIAA PAPER 88-3633)

Disturbing forces and moments are calculated using the FLOW-3D finite difference code for a space-based oxygen tank under a suddenly applied settling acceleration for a case with a simultaneous liquid outflow and a case with no such outflow. Results show that the two conditions result in very different dynamic disturbances. The code accuracy is evaluated as part of the calculations and is shown to be adequate. Results also indicate that the storage tank geometry has a significant effect on the resulting disturbances. Author

A88-49714* Georgia Inst. of Tech., Atlanta.

FREQUENCY DOMAIN SOLUTIONS TO MULTI-DEGREE-OF-FREEDOM, DRY FRICTION DAMPED SYSTEMS

A. A. FERRI (Georgia Institute of Technology, Atlanta) and E. H. DOWELL (Duke University, Durham, NC) Journal of Sound and

Vibration (ISSN 0022-460X), vol. 124, July 22, 1988, p. 207-224. refs
(Contract AF-AFOSR-83-0346; NAG3-516)

Dry friction damping has been considered as a means of increasing the passive damping of a variety of systems including large space structures and turbomachinery blades. However, dry friction is highly nonlinear, and hence, analytical investigations are difficult to perform. Here, a multiharmonic, frequency domain solution technique is developed and applied to a multi-degree-of-freedom, dry friction damped system. It is seen that the multiharmonic method is more accurate than traditional, one-harmonic solution methods. The method also compares favorably with time integration. Finally, comparisons are made with experimental results. Author

A88-49743

COMPATIBILITY OF MICROGRAVITY EXPERIMENTS WITH SPACECRAFT DISTURBANCES

B. FEUERBACHER, H. HAMACHER, and R. JILG (DFVLR, Institut fuer Raumsimulation, Cologne, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, May-June 1988, p. 145-151. refs

A simple model which permits analysis of the sensitivity of microgravity experiments to residual accelerations has been developed. The results are compared with the disturbance characteristics of typical spacecraft configurations in order to assess compatibility. Experiment sensitivity is characterized by an increasing disturbance tolerance at higher frequencies and a constant limit at low frequencies. The residual acceleration spectra of space structures show quasi-steady and dynamic contributions which vary with orbit attitude and configuration. The calculations are validated by comparison with measured microgravity disturbances during Spacelab flights and are then extrapolated to Space Station operations. Author

A88-49914#

A VARIABLE STRUCTURE CONTROL APPROACH TO FLEXIBLE SPACECRAFTS

WEIBING GAO, MIAN CHENG, and WENLING ZENG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, May 1988, p. A274-A280. In Chinese, with abstract in English. refs

The approach of variable structure control strategy is applied to the control problems of large flexible spacecrafts, taking the nonlinear forces into consideration. As the 'assumed modes method' is employed, the measurement technique for obtaining the mode coordinates is studied. After the analysis of a suggested reaching law, the overall nonlinear feedback control law is established. This reaching law guarantees an exponential reaching velocity and a finite reaching time by diminishing the chattering phenomenon. It is assumed that the torque may be more adequate than the force used as control actions. Author

A88-50095

METHOD FOR THE EXPERIMENTAL DETERMINATION OF THE FREQUENCY CHARACTERISTICS OF AN ELASTIC FLIGHT VEHICLE WITH A DIGITAL CONTROL SYSTEM [METODY EKSPERIMENTAL'NOGO OPREDELENIIA CHASTOTNYKH KHARAKTERISTIK UPRUGOGO LETATEL'NOGO APPARATA S TSIFROVOI SISTEMOI UPRAVLENIIA]

V. M. KUVSHINOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 54-68. In Russian. refs

Several frequency-analyzer-based techniques for determining the frequency characteristics of flight vehicles with a digital control system in the elastic-vibration frequency range of the structure are examined. Errors due to the finite measurement time are assessed, and simple relationships for choosing the appropriate measurement time are proposed. B.J.

A88-50165*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

POLE/ZERO CANCELLATIONS IN FLEXIBLE SPACE STRUCTURES

TREVOR WILLIAMS and JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 33-40. refs
(AIAA PAPER 88-4055)

A practical objective in the control of flexible space structures is to minimize the effects of vibrational dynamics at certain specified points on a structure. State feedback can be used to address this question by creating closed-loop modes which are unobservable at these points, and so do not contribute to the measured response. In the frequency domain, such modes correspond to pole/zero cancellations in the closed loop system. This paper analyzes the problem of pole/zero cancellation in flexible structures, making full use of the second-order form of such systems. An explicit expression is derived for the unique state feedback gain with minimum norm which cancels all open-loop zeros. Furthermore, the properties of the residual poles that remain observable in the closed-loop system are studied, and their stability proven for the case of colocated sensors and actuators. Author

A88-50167#

SENSORS, ACTUATORS, AND HYPERSTABILITY OF STRUCTURES

MICHAEL E. STIEBER (CDC, Communications Research Centre, Ottawa, Canada) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 51-56. refs
(AIAA PAPER 88-4057)

The design of robust adaptive controllers for large space flexible structures with poorly known time-varying nonlinear dynamics is considered in an analytical review, with a focus on the hyperstability (HS) criterion (guaranteeing stability of interconnected systems) and the selection and placement of sensors and actuators. A definition of HS is presented; the properties of hyperstable systems are listed; sufficient and necessary conditions for HS are outlined; conditions on sensor types and placement are summarized; and problems involving absolute positioning, asymptotic HS, and the use of 'nonallowed' sensors are briefly considered. Colocation of sensors and actuators is found to be preferable because it is sufficient (although not necessary) for HS. T.K.

A88-50168#

A DISTURBANCE MODEL FOR THE OPTIMIZATION OF CONTROL/STRUCTURE INTERACTIONS FOR FLEXIBLE DYNAMIC SYSTEMS

G. L. SLATER (Cincinnati, University, OH) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 57-63. USAF-supported research. refs
(AIAA PAPER 88-4058)

This paper deals with a technique for the integrated optimization of structure and control in the design of flexible spacecraft and other flexible systems. This current approach uses the response to dynamic inputs and constraint limits to establish trade-offs between control energy and structural mass. This approach gives a concise variational approach to total system optimization and eliminates the need to specify rather arbitrary trade-offs between control energy and structural mass. Results give an explicit dependency between structural stiffness (hence mass), disturbance magnitude, control energy available and deflection constraints. For the special case of linear controls and quadratic constraints the problem reduces to a standard LQG problem plus a structure optimization. The method is general, however, and can be extended to more general problems such as output feedback, nonlinear controls, and slew optimization. Author

A88-50169*# DYNACS Engineering Co., Inc., Clearwater, FL.
EFFECTS OF NONLINEAR DAMPING IN FLEXIBLE SPACE STRUCTURES
ANREN HU (DYNACS Engineering Co., Inc., Clearwater, FL) and LAWRENCE W. TAYLOR (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 64-73. refs
(AIAA PAPER 88-4059)

The classical Krylov-Bogoliubov 'averaging' technique is used to study a class of nonlinear damping models, for which the damping force is proportional to the product of positive integer or fractional power of absolute values of displacement and that of velocity. The results are compared with linear viscous damping models. The amplitude decrement of free vibration for a single mode system with nonlinear models depends not only on damping ratio, but also on the initial amplitude, the time to measure the response, frequency of the system, and the powers of displacement and velocity. For the distributed system, the action of nonlinear damping is found to reduce energy of the system as well as to pass energy to higher modes. Experimental evidence such as in Spacecraft Control Laboratory Experiment seems to support the need for nonlinear models. Author

A88-50170#
MODELING OF NON-COLLOCATED STRUCTURAL CONTROL SYSTEMS
V. A. SPECTOR (TRW, Inc., Redondo Beach, CA) and H. FLASHNER (Southern California, University, Los Angeles) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 74-83. Research supported by TRW, Inc. refs
(Contract NSF MSM-85-05331)
(AIAA PAPER 88-4060)

The generic properties of structural modeling pertinent to structural control are discussed, with emphasis on noncollocated systems. Analysis is performed on a representative example of a pinned-free Euler-Bernoulli beam with end-point inertia and distributed sensors. Analysis in the wavenumber plane highlights the crucial qualitative characteristics common to all structural systems. High sensitivity of the transfer-function zeros to errors in model parameters and sensor locations is demonstrated. The existence of finite right-half-plane zeros in noncollocated systems, along with this high sensitivity, further complicates noncollocated control design. A numerical method for accurate computation of the transfer-function zeros in proposed. Author

A88-50189*# Ohio State Univ., Columbus.
TWO CONTROLLER DESIGN APPROACHES FOR DECENTRALIZED SYSTEMS
U. OZGUNER, F. KHORRAMI, and A. IFTAR (Ohio State University, Columbus) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 237-244. Research supported by Lawrence Livermore National Laboratory. refs
(Contract NAG1-720)
(AIAA PAPER 88-4083)

Two different philosophies for designing the controllers of decentralized systems are considered within a quadratic regulator framework which is generalized to admit decentralized frequency weighting. In the first approach, the total system model is examined, and the feedback strategy for each channel or subsystem is determined. In the second approach, separate, possibly overlapping, and uncoupled models are analyzed for each channel, and the results can be combined to study the original system. The two methods are applied to the example of a model of the NASA COFS Mast Flight System. R.R.

A88-50191#
A DISTRIBUTED FINITE ELEMENT MODELING AND CONTROL APPROACH FOR LARGE FLEXIBLE STRUCTURES
K. DAVID YOUNG (Lawrence Livermore National Laboratory, Livermore, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 253-263. refs
(Contract W-7405-ENG-48)
(AIAA PAPER 88-4085)

A framework for the design of decentralized controllers for large flexible structures is proposed which integrates the finite element modeling and control design phases. The integrated modeling and control design tasks are distributed among the individual components from which the large flexible structure is contructed using the Controlled Component Synthesis method. The method allows controlled components to be built and assembled into a controlled flexible structure that meets performance specifications. Connections are made between controlled component synthesis and existing large scale system model reduction and decomposition techniques. R.R.

A88-50193*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
GRAMMIANS AND MODEL REDUCTION IN LIMITED TIME AND FREQUENCY INTERVALS
WODEK GAWRONSKI and JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 275-285. refs
(AIAA PAPER 88-4087)

In this paper the controllability and observability grammians in limited time and frequency intervals are studied, and used for model reduction. In balanced and modal coordinates a near-optimal reduction procedure is developed, yielding the reduction error (norm of the difference between the output of the original system and the reduced model) almost minimal. Several examples are given to illustrate the concept for model reduction of continuous- and discrete-time systems, stable and unstable systems, in limited tim or/and frequency interval. Finally, the model reduction of a flexible truss structure is presented. Author

A88-50199#
REDUNDANCY CONTROL OF A FREE-FLYING TELEROBOT
DAVID AKIN (MIT, Cambridge, MA) and JOHN SPOFFORD IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 347-357. refs
(AIAA PAPER 88-4094)

The 'coordinated control' algorithm allows the simultaneous reduced-order control of a vehicle and its attached manipulator. An entire telerobot system is thereby controlled by commanding the end-effector inertially with respect to the task, through a unified dynamic system treatment which considers the free-flying teleoperator as a redundant manipulator. The coordinated trajectory algorithm is a blend of two modes: (1) gradient pseudoinverse trajectory control, which uses both vehicle thrust and manipulator motion, and (2) reaction-compensation trajectory control, which allows the base to react freely to manipulator interaction torques. O.C.

A88-50201#
ATTITUDED TUMBLING DUE TO FLEXIBILITY IN SATELLITE MOUNTED ROBOTS
RICHARD W. LONGMAN (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 365-373.
(AIAA PAPER 88-4096)

Future satellite mounted robots will often be required to manipulate load masses that are not insignificant compared to the satellite mass. These robots will also exhibit structural flexibility because of their size and the need for a light weight design. Here it is shown by simple example, that the structural vibrations induced by robot manipulations will generally try to tumble the spacecraft. The satellite attitude control system will have to compensate for this attitude disturbance. A general formalism is developed to determine the attitude control torque which must be generated to counteract the flexibility effects and the robot motion. The results are useful for analysis and evaluation of attitude control, and with proper instrumentation might serve as the control law in a feedforward control signal. Author

A88-50209*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

NASA OFFICE OF SPACE SCIENCES AND APPLICATIONS STUDY ON SPACE STATION ATTACHED PAYLOAD POINTING

R. A. LASKIN, J. M. ESTUS, Y. H. LIN, J. T. SPANOS, and C. M. SATTER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 430-443. refs
(AIAA PAPER 88-4105)

A study has been conducted to determine the articulated-pointing requirements of a suite of instruments carried by the NASA Space Station, and define a pointing system architecture accomodating those requirements. It is found that these pointing requirements are sufficiently exacting, and the Space Station's disturbance environment sufficiently severe, to preclude the successful use of a conventional gimbal-pointing system; a gimbaled system incorporating an isolation stage is judged capable of furnishing the requisite levels of pointing performance. O.C.

A88-50233*# Texas Univ., Austin.

A NEW MOMENTUM MANAGEMENT CONTROLLER FOR THE SPACE STATION

B. WIE, K. W. BYUN, V. W. WARREN (Texas, University, Austin), D. GELLER, D. LONG, and J. SUNKEL (NASA, Johnson Space Center, Houston, TX) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 677-687. refs
(AIAA PAPER 88-4132)

A new approach to CMG (control moment gyro) momentum management and attitude control of the Space Station is developed. The control algorithm utilizes both the gravity-gradient and gyroscopic torques to seek torque equilibrium attitude in the presence of secular and cyclic disturbances. Depending upon mission requirements, either pitch attitude or pitch-axis CMG momentum can be held constant; yaw attitude and roll-axis CMG momentum can be held constant, while roll attitude and yaw-axis CMG momentum cannot be held constant. As a result, the overall attitude and CMG momentum oscillations caused by cyclic aero-dynamic disturbances are minimized. A state feedback controller with minimal computer storage requirement for gain scheduling is also developed. The overall closed-loop system is stable for + or - 30 percent inertia matrix variations and has more than + or - 10 dB and 45 deg stability margins in each loop. Author

A88-50246#

SYSTEM IDENTIFICATION AND CONTROL OF THE TRUSS EXPERIMENT - A RETROSPECTIVE

MICHAEL S. LUKICH (TRW, Inc., Redondo Beach, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 821-831. refs
(AIAA PAPER 88-4152)

Research on an experimentally validated system identification and control technology for large space structures is reviewed. Brief synopses of theoretical developments in system identification, multivariable control system design, and passive/active control are given. The emphasis is on the the results of the truss experiment and the lessons learned from them. C.D.

A88-50247*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ADAPTIVE CONTROL EXPERIMENT WITH A LARGE FLEXIBLE STRUCTURE

CHE-HANG CHARLES IH, DAVID S. BAYARD, SHYH JONG WANG, and DANIEL B. ELDRED (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 832-851. refs
(AIAA PAPER 88-4153)

A large space antenna-like ground experiment structure has been developed for conducting research and validation of advanced control technology. A set of proof-of-concept adaptive control experiments for transient and initial deflection regulation with a small set of sensors and actuators were conducted. Very limited knowledge of the plant dynamics and its environment was used in the design of the adaptive controller so that performance could be demonstrated under conditions of gross underlying uncertainties. High performance has been observed under such stringent conditions. These experiments have established a baseline for future studies involving more complex hardware and environmental conditions, and utilizing additional sets of sensors and actuators. Author

A88-50248#

DYNAMICS AND CONTROL OF EXPERIMENTAL TENDON CONTROL SYSTEM FOR FLEXIBLE SPACE STRUCTURE

Y. MUROTSU, H. OKUBO, K. SENDA (Osaka Prefecture, University, Sakai, Japan), F. TERUI, and K. SHINODA IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 852-860. refs
(AIAA PAPER 88-4154)

A mathematical model of dynamics for a composite system of a beam/tendon-actuator is developed here using a finite element method. The model is used to design a low-order modal controller. The relation between the dynamics of the tendon actuator and the control system design is investigated for the cases when the rigidity of the tendons is very high and low. C.D.

A88-50259#

ON-LINE MEASUREMENT CONFIGURATION STRATEGIES FOR DISCRETE-TIME SYSTEMS

YAAKOV OSHMAN (New York, State University, Buffalo) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 948-957. refs
(AIAA PAPER 88-4168)

This paper introduces a new measurement system optimization technique which can be implemented on-line in time-varying, discrete-time systems. It considers a case in which several measurement subsystems are available each one of which may serve to drive a state estimation algorithm. However, due to practical implementation constraints, only one of these subsystems can actually be used at a measurement-update. An algorithm is needed, by which the optimal measurement subsystem to be used is selected at each measurement configuration epoch. The approach taken at solving this problem is based on using the square root V-Lambda information filter as the underlying state estimation algorithm. This algorithm continuously provides its user with the spectral factors of the estimation error covariance matrix, which are, in turn, used in this work as the basis for an on-line decision procedure by which the optimal measurement strategy is derived. A numerical example is presented, which demonstrates the performance of the new algorithm. Author

A88-50261#
GUIDANCE AND CONTROL FOR COOPERATIVE TETHER-MEDIATED ORBITAL RENDEZVOUS
DALE G. STUART (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 964-974. refs
(AIAA PAPER 88-4170)

This paper presents a viable guidance algorithm for performing a tether-mediated rendezvous, optimizing the rendezvous state such that the minimum total maneuvering effort is required of two vehicles performing the rendezvous. The algorithm's feasibility and practicality are analyzed under near-realistic operating conditions by simulating perturbations of a free-flying pursuit vehicle (PV) from its nominal rendezvous trajectory and then observing the capability of the algorithm to determine corrective maneuvers that would lead to a successful rendezvous. Fuel requirements, time spent within proximity of the target, and thruster failure tolerances are considered. Results indicate that the algorithm performs well even with large PV perturbations. The resulting total fuel cost for both vehicles is less than what would be required by having one vehicle alone perform the rendezvous maneuvers. C.D.

A88-50262#
TWO NON-LINEAR CONTROL APPROACHES FOR RETRIEVAL OF A THRUSTING TETHERED SUB-SATELLITE
D. J. PINES, A. H. VON FLOTOW (MIT, Cambridge, MA), and D. C. REDDING (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 975-983. refs
(AIAA PAPER 88-4171)

This paper presents an analysis of the dynamics and control of the pitch and roll motion during retrieval of a Tethered Satellite System, consisting of the Space Shuttle Orbiter and the tethered satellite. Two nonlinear control designs are investigated and compared. The first approach uses visual observation of the line of sight angle and phase plane switch logic to generate simple pilotage rules for orbiter pilots. The second uses a controller designed using computational sliding mode techniques. It assumes more precise sensing of system state and would be implemented using the Orbiter and sub-satellite jets. Author

A88-50263#
LIBRATION DAMPING OF A TETHERED SATELLITE USING RATE ONLY CONTROL
W. R. DAVIS and A. K. BANERJEE (Lockheed Missiles and Space Co., Sunnyvale, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 984-994. refs
(AIAA PAPER 88-4172)

A control law specifying tether reel in/out rate based on measurement of tether libration angles and their rates has been formulated and evaluated using a simple model of a tethered satellite. The results indicate that both out-of-plane and in-plane librations can be damped by varying the length of the tether by about 10 percent of its length. Time required to reduce out-of-plane librations by a factor of 10 is less than seven orbital periods. Significant improvement in control of in-plane librations are shown in that these are damped in less than one orbit period. Control of the damped configuration to a nominal desired length is also included. A FORTRAN code for the control logic is given. Author

A88-50265*# Texas Univ., Austin.
AN APPROXIMATE ATMOSPHERIC GUIDANCE LAW FOR AEROASSISTED PLANE CHANGE MANEUVERS
JASON L. SPEYER and EDWIN Z. CRUES (Texas, University, Austin) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1006-1014. refs
(Contract JPL-956414)
(AIAA PAPER 88-4174)

An approximate optimal guidance law for the aeroassisted plane change problem is presented which is based upon an expansion of the Hamilton-Jacobi-Bellman equation with respect to the small parameter of Breakwell et al. (1985). The present law maximizes the final velocity of the reentry vehicle while meeting terminal constraints on altitude, flight path angle, and heading angle. The integrable zeroth-order solution found when the small parameter is set to zero corresponds to a solution of the problem where the aerodynamic forces dominate the inertial forces. Higher order solutions in the expansion are obtained from the solution of linear partial differential equations requiring only quadrature integration. R.R.

A88-50266*# Georgia Inst. of Tech., Atlanta.
A NEAR OPTIMAL GUIDANCE ALGORITHM FOR AERO-ASSISTED ORBIT TRANSFER
ANTHONY J. CALISE and GYOUNG H. BAE (Georgia Institute of Technology, Atlanta) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1015-1019. refs
(Contract NAG1-660)
(AIAA PAPER 88-4175)

The paper presents a near optimal guidance algorithm for aero-assited orbit plane change, based on minimizing the energy loss during the atmospheric portion of the maneuver. The guidance algorithm makes use of recent results obtained from energy state approximations and singular perturbation analysis of optimal heading change for a hypersonic gliding vehicle. This earlier work ignored the terminal constraint on altitude needed to insure that the vehicle exits that atmosphere. Thus, the resulting guidance algorithm was only appropriate for maneuvering reentry vehicle guidance. In the context of singular perturbation theory, a constraint on final altitude gives rise to a difficult terminal boundary layer problem, which cannot be solved in closed form. This paper will demonstrate the near optimality of a predictive/corrective guidance algorithm for the terminal maneuver. Comparisons are made to numerically optimized trajectories for a range or orbit plane angles. Author

A88-50280#
PILOTED EARTH POINTING OF A SPINNING GEOSYNCHRONOUS SATELLITE
D. D. FITZGERALD, R. B. SHERWOOD, and A. B. SIMMONS (TRW, Inc., Redondo Beach, CA) AIAA, Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988. 12 p.
(AIAA PAPER 88-4130)

The development of a ground controlled earth acquisition for a geosynchronous satellite is discussed. The satellite's normal attitude control capabilities and the provision available for back-up ground commanding are examined. The theoretical approach used to implement the manual earth acquisition is presented. This implementation consists of several hours of continuous, time-critical, man-in-the-loop commanding. The refinements made to the operation as a result of knowledge gained in the hands-on rehearsals are given. R.B.

A88-50362#
AN ALTERNATE TRANSITION FROM THE LAGRANGIAN OF A SATELLITE TO EQUATIONS OF MOTION
S. R. MARANDI and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 79-93. refs
(AIAA PAPER 88-4221)

A procedure is outlined for a conservative system which makes it possible to go from a Lagrangian of a librating system to the corresponding equations of motion in the Eulerian form. The transition does not require a choice of rotational coordinates and makes use of angular velocities and direction cosines directly. The procedure thus synthesizes attractive features of two classical approaches and has far reaching consequences; it is particularly useful in formulating equations of motion for complex flexible systems of contemporary interest. For the case of a satellite with two flexible plate-type appendages, for example, the approach reduced the formulation time to one-third. The basic mathematical concepts are briefly touched upon in the beginning which help explain the subsequent development. Author

A88-50367#

A SLEW MANEUVER EXPERIMENT OF MISSION FUNCTION CONTROL

HIRONORI FUJII (Tokyo Metropolitan Institute of Technology, Hino, Japan) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 130-134. refs

(AIAA PAPER 88-4226)

A control algorithm, named 'The Mission Function Control', is experimentally demonstrated and verified its validity on slew maneuver of a flexible space structure model. The mission function control algorithm is to use a Liapunov-type function consists of generalized energy functions. The model is a rigid main body equipped with a flexible beam and is controlled to slew in a horizontal plane by a torque motor attached to the main body. The vibrational motion of the flexible beam is sensed by strain gages as bending moment and shearing force at the root of the beam after analytical reduction of the algorithm. Results of the experiment show simple implementation of the algorithm and such an excellent controlled behavior of the slew maneuver as control robustness. Author

A88-50383#

ANALYTICAL EXPRESSIONS FOR VIBRATORY DISPLACEMENTS OF DEPLOYING APPENDAGES

A. K. MISRA (McGill University, Montreal, Canada) and S. KALAYCIOGLU IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 270-277. refs

(AIAA PAPER 88-4250)

For beam-type appendages, solutions are presented for uniform extension rate, exponential extension and deployment where the square of the length varies linearly with time. For tethered systems, an analytical solution is presented for the common exponential deployment (or retrieval). The analytical solutions seem to be quite close to the more expensive numerical solutions. If the length changes, the amplitude of transverse vibration varies as L(exp 1/2) for beam-type and L(exp - 1/4) for tether-type appendages. Author

A88-50384*# Howard Univ., Washington, DC.

THE DYNAMICS AND CONTROL OF THE ORBITING SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE) DURING STATION KEEPING

PETER M. BAINUM and CHEICK M. DIARRA (Howard University, Washington, DC) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 278-285. refs

(Contract NSG-1414)

(AIAA PAPER 88-4252)

A mathematical model is developed to predict the dynamics of the proposed orbiting Spacecraft Control Laboratory Experiment during the station keeping phase. The Shuttle as well as the reflector are assumed to be rigid, the mast is flexible and is assumed to undergo elastic displacements very small as compared with its length. The equations of motion are derived using a Newton-Euler formulation. The model includes the effects of gravity, flexibility, and orbital dynamics. The control is assumed to be provided to the system through the Shuttle's three torquers, and through six actuators located by pairs at two points on the mast and at the mass center of the reflector. At each of the locations, an actuator acts parallel to the roll axis while the other one acts parallel to the pitch axis. It is seen that, in the presence of gravity-gradient torques in the system dynamics, the system assumes a new equilibrium position about which the equations must be linearized, primarily due to the offset in the mast attachment point to the reflector. The linear regulator theory is used to derive control laws for the linear model of the SCOLE including the first four flexible modes. Numerical results confirm the robustness of this control strategy for station keeping with maximum control efforts significantly below saturation levels. Author

A88-50385#

A POLE PLACEMENT TECHNIQUE FOR VIBRATION SUPPRESSION OF FLEXIBLE STRUCTURES

NELSON G. CREAMER (General Research Corp., Arlington, VA) and JOHN L. JUNKINS (Texas A & M University, College Station) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 286-29 refs

(AIAA PAPER 88-4254)

A novel pole placement technique is developed for stabilizing an initially undamped (or lightly damped) structure using symmetric 'structural' feedback. The feedback matrices are expressed in terms of prescribed symmetric, positive semi-definite submatrices and unknown scale factors (gain elements). The gain elements are designed to place a set of target eigenvalues at (or near) their desired locations by imposing state space orthogonality conditions which the closed-loop structure must satisfy. A standard linear programming problem is formulated which not only places the target eigenvalues but also minimizes the modal dissipation and potential energy of the target modes and satisfies actuator force limits. In addition, the untargeted, higher frequency modes are guaranteed to be stable due to the positivity of the gain submatrices. Author

A88-50386#

AN OPTIMAL MANEUVER CONTROL METHOD FOR THE SPACECRAFT WITH FLEXIBLE APPENDAGES

D. LIU, D. M. YANG, W. P. ZHANG (Harbin Institute of Technology, People's Republic of China), and J. XI IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 294-300. Research sponsored by the National Natural Science Foundation of China. refs

(AIAA PAPER 88-4255)

A maneuver control method for a system of rigid and flexible bodies is presented which can suppress the elastic vibration mode and avoids the two point boundary value problem. The method requires that vibration parameters be determined before optimal controls are applied to the system. The method can be used to restrict or eliminate elastic vibration, liquid sloshing, or pendulum oscillation. The approach can be developed to suppress two of these vibrations simultaneously. R.B.

A88-50398#

A FORMULATION FOR STUDYING DYNAMICS AND CONTROL OF THE SPACE STATION BASED MRMS AND ITS APPLICATION

Y. MORITA and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 401-409. refs

(Contract NSERC-0032682)

(AIAA PAPER 88-4269)

A relatively general formulation for studying dynamics of a flexible Mobile Remote Manipulator System (MRMS), supported by an orbiting flexible platform, is developed using the Lagrangian approach with generalized forces accounting for the environmental effects, damping and control. The flexible members are treated as continua and their flexural deformations are represented by a series of admissible functions. The computational algorithm is so structured as to isolate the effects of various system parameters thus helping in assessment of their relative importance. Appplication of the general formulation, illustrated through several typical MRMS configurations of practical importance, reveals complex interactions between vibrational and librational degrees of freedom, in the presence of MRMS maneuver, over a range of system parameters and initial conditions. Effectiveness of the formulation is also demonstrated through another illustrative example of the SCOLE configuration representing the Shuttle based flexible beam supporting a rigid reflector plate at its end. The information is fundamental to the design of the manipulator and the associated controls system. Author

A88-50407#

TRANSIENT DYNAMICS OF THE TETHER ELEVATOR/CRAWLER SYSTEM

M. COSMO, E. C. LORENZINI (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA), S. VETRELLA, and A. MOCCIA (Napoli, Universita, Naples, Italy) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 480-489. refs
(AIAA PAPER 88-4280)

This paper describes the dynamics and control of a 4-mass tethered system, attached to the Space Station, for conducting micro-g and variable-g experiments. After deriving the two-dimensional equations of motion by means of the Lagrangian function, the eigenfrequencies and eigenvectors of the system have been computed. Control algorithms have been devised to damp out the fundamental oscillations of the system, namely in-plane libration, lateral deflections, and tethers' longitudinal oscillations. Numerical results show that the control strategies adopted can effectively damp the oscillations excited during transient phases of the system dynamics such as the end of the deployment phase. Author

A88-50409#

OUT OF PLANE MANEUVERING WITH TETHERED SATELLITES

M. D. HAYNES and D. G. BODEN (U.S. Air Force Academy, Colorado Springs, CO) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 498-502.
(AIAA PAPER 88-4282)

This paper consists of an investigation into the use of a tethered satellite system to maneuver a parent satellite out of the orbital plane, and return the satellite to its initial orbit. This study is directed at obtaining a more efficient method of enabling the satellite to avoid an inplane intercept. The use of a tethered satellite system instead of a conventional delta v maneuver will result in an overall weight savings, greater simplicity in deployment, and a reusable maneuver capability. Author

A88-50428#

A FORMULATION FOR STUDYING DYNAMICS OF INTERCONNECTED BODIES WITH APPLICATION

A. C. NG and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 660-668. refs
(Contract NSERC-58-0029)
(AIAA PAPER 88-4303)

A relative general formulation for studying the dynamics of spacecraft with interconnected flexible bodies is presented accounting for thermal deformations and transverse vibrations of the structural members. In addition, the shift in the center of mass of the system and the slewing maneuvers of the members are incorporated. The formulation can be applied to study the U.S. proposed Space Station as well as a large class of present and future spacecraft. An example illustrates application of the formulation. The model under study is a satellite with a central rigid body and a pair of beam-type appendages. The librational and vibrational responses of the system with and without thermal deformation are compared. The results show that in circular orbits, under a critical combination of system parameters and initial conditions, thermal deformation can lead to instability. Author

A88-50429#

A DYNAMICAL STUDY OF THE PROPOSED SPACE STATION TYPE CONFIGURATION

A. SULEMAN and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 669-680.
(Contract NSERC-A-2181)
(AIAA PAPER 88-4304)

The planar libration-vibration interaction dynamics of the proposed Space Station is investigated using a simplified model where the keel and solar panels are represented as beams and the central pressurized modules as a rigid body. Following a Lagrangian analysis of the governing nonlinear nonautonomous and coupled equations of motion, a finite element analysis is used to study the first seven system modes and associated frequencies. A parametric analysis of the system librational and vibrational response is then presented. Finally, a closed-form solution of the simplified nonlinear problem is obtained using the variation of parameters method. R.R.

A88-50430#

INTEGRATED STRUCTURAL/CONTROLLER OPTIMIZATION OF LARGE SPACE STRUCTURES

SCOT K. MORRISON, YINYU YE, CHARLES Z. GREGORY, JR., ROBERT L. KOSUT (Integrated Systems, Inc., Santa Clara, CA), and MARC E. REGELBRUGGE (Lockheed Research Laboratories, Palo Alto, CA) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 681-688. refs
(Contract F29601-86-C-0243)
(AIAA PAPER 88-4305)

A method for optimizing the closed-loop disturbance rejection capabilities of a large-space-structure is presented herein. The procedure uses two levels of model reduction, one to an evaluation model, and another to a controlled subspace. The line-of-sight pointing error of optical elements mounted on the spacecraft is used to evaluate the system performance. Optimization results are obtained for both the open-loop and closed-loop system, with several different sets of constraints. The results indicate that combined structural/controller optimization yields superior disturbance rejection qualities than open-loop optimization followed by optimal control implementation. Author

A88-50431#

DESIGN OF AN ON-BOARD ANTENNA POINTING CONTROL SYSTEM FOR COMMUNICATION SATELLITES

YOICHI KAWAKAMI, HIROSHI HOJO, and MASAZUMI UEBA (Nippon Telegraph and Telephone Public Corp., Radio Communication Systems Laboratories, Kanagawa, Japan) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 689-694.
(AIAA PAPER 88-4306)

This paper describes system design methods of an on-board antenna pointing control system necessary for communication satellites in the 1990s. Four system configurations were studied for a typical antenna system. The system consists of two reflectors of about 3 meters diameter, and is required to maintain a high pointing accuracy requirement. A new system which consists of two control systems, an attitude control system and an antenna

drive control system, was selected by the antenna pointing error analysis. New parameters are applied to the control system design in order to estimate interaction between two control systems, and dynamics with a flexible structure was studied for design of both the antenna drive control system and the antenna structures.
Author

A88-50432#
ACTIVE CONTROL EXPERIMENT USING PROOF MASS ACTUATORS
T. CRISTLER and R. A. CALICO (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 695-703.
(AIAA PAPER 88-4307)

An experimental investigation of a vertically suspended cantilevered beam was performed in order to study the control of large space structures. In the present experimental arrangement, control forces were provided by linear proof mass actuators and structural motion was measured using peizoelectric accelerometers. The structure provided six vibration modes in the designated control bandwidth. The simultaneous operation of separate controllers while maintaining overall system stability was demonstrated, along with suppression of a mode from one of the controllers. Although the proof mass actuators were shown to be viable structural control devices, they have limited force output at low frequencies. R.R.

A88-50438*# Columbia Univ., New York, NY.
A MATHEMATICAL THEORY OF LEARNING CONTROL FOR LINEAR DISCRETE MULTIVARIABLE SYSTEMS
MINH PHAN and RICHARD W. LONGMAN (Columbia University, New York) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 740-746. refs
(Contract NAG1-649)
(AIAA PAPER 88-4313)

When tracking control systems are used in repetitive operations such as robots in various manufacturing processes, the controller will make the same errors repeatedly. Here consideration is given to learning controllers that look at the tracking errors in each repetition of the process and adjust the control to decrease these errors in the next repetition. A general formalism is developed for learning control of discrete-time (time-varying or time-invariant) linear multivariable systems. Methods of specifying a desired trajectory (such that the trajectory can actually be performed by the discrete system) are discussed, and learning controllers are developed. Stability criteria are obtained which are relatively easy to use to insure convergence of the learning process, and proper gain settings are discussed in light of measurement noise and system uncertainties. Author

A88-50440#
ACCOMMODATION OF KINEMATIC DISTURBANCES DURING A MINIMUM-TIME MANEUVER OF A FLEXIBLE SPACECRAFT
YAAKOV SHARONY and LEONARD MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) AIAA and AAS, Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988. 17 p. refs
(Contract F33615-86-C-3233)
(AIAA PAPER 88-4253)

This paper is concerned with control of the perturbations experienced by a flexible spacecraft during a minimum-time maneuver. The spacecraft is modeled as a flexible appendage attached to a rigid hub. The perturbations consist of rigid-body deviations and elastic vibration. The vibration is described by a linear, time-varying set of ordinary differential equations subjected to piecewise-constant disturbances caused by inertial forces resulting from the maneuver. The control is carried out during the maneuver period, which is relatively short, and it uses an observer that estimates the controlled state and part of the disturbance vector. The controller is divided into an optimal finite-time linear quadratic regulator for the reduced-order model and a disturbance-accommodation control that minimizes a weighted norm spanning the full modeled state. The controller is designed to mitigate the effects of control and observation spillover, as well as of modeling errors. The developments are illustrated by means of a numerical example. Author

A88-50441#
CONTROL OF SPACECRAFT WITH MULTI-TARGETED FLEXIBLE ANTENNAS
LEONARD MEIROVITCH and MOON K. KWAK (Virginia Polytechnic Institute and State University, Blacksburg) AIAA and AAS, Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988. 9 p. refs
(Contract F49620-88-C-0044)
(AIAA PAPER 88-4268)

This paper is concerned with the problem of reorienting the line of sight of a given number of flexible antennas in a spacecraft. The maneuver of the antennas is carried out according to a minimum-time policy, which implies bang-bang control. Regarding the maneuver angular motion of the antennas as known, the equations of motion contain time-dependent terms in the form of coefficients and persistent disturbances. The control of the elastic vibration and of the rigid-body motions of the spacecraft caused by the maneuver is implemented by means of a proportional-plus-integral control. The approach is demonstrated by means of a numerical example in which a spacecraft consisting of a rigid platform and two maneuvering flexible antennas is controlled. Author

A88-50586#
AERODYNAMIC DESIGN OF A VARIABLE-BEND VEHICLE
G. F. POLANSKY and W. H. RUTLEDGE (Sandia National Laboratories, Albuquerque, NM) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 94-102. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 88-4340)

An examination is made of the use of variable bending as a means of control in supersonic and hypersonic maneuvering vehicles, with a view to the amelioration of the large hinge moments that have thus far prevented their realization. A procedure is devised for the efficient design of a variable-bend geometry vehicle for a given set of system constraints, giving attention to the selection of vehicle parameters which will generate the minimum hinge moments for trimmed flight. O.C.

A88-50789
INTERNATIONAL MODAL ANALYSIS CONFERENCE, 5TH, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, LONDON, ENGLAND, APR. 6-9, 1987, PROCEEDINGS. VOLUMES 1 & 2
Conference sponsored by Union College. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. Vol. 1, 853 p.; vol. 2, 915 p. For individual items see A88-50790 to A88-50900.

Various papers on modal analysis and testing are presented. The general topics addressed include: experimental case histories, analytical methods, structural dynamics modification, linking analysis and test, processing modal data, modal test methods, seismic topics, modal techniques for rotating machinery, modeling structures, substructuring, and noise/acoustic topics. Also considered are: experimental techniques, vehicular topics, space structures, machinery diagnostics, nonlinear structures, design methods, damping, ship-related topics, transducers and instrumentation topics, finite element analysis, and modal analysis software. C.D.

A88-50809
IDENTIFICATION OF A COMPLEX SATELLITE MODEL BY MEANS OF MODAL SYNTHESIS
WERNER SACHS (DFVLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: International Modal Analysis

Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 468-475. refs

A study conducted in order to answer many of the open questions in the field of modal synthesis, with particular attention given to practical applicability, is summarized. The design of the interfaces, test condition of the substructures, sensitivity of the procedure dependent on the measuring errors, convergence acceleration, interface loading, and damping influences are considered. A new representation of the synthesis algorithm used here is introduced. C.D.

A88-50818

SPACE STATION DYNAMIC ANALYSIS

PREM B. D'CRUZ (Structural Dynamics Research Corp., Milford, OH) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 544-547. refs

This paper describes an application example of computer aided engineering techniques used to investigate the structural dynamnic characteristics of one of NASA's proposed Space Station configurations. The example investigations involved predicting vibration levels due to orbit reboost, Space Shuttle berthing and the unbalance force of the control moment gyro. Component mode synthesis was used to assemble and solve the system model of the Space Station. A numerical comparison of two popular component mode synthesis modeling methods, the fixed interface Craig-Bampton method and the free interface residual flexibility method was also performed for this application. Using the systems approach helps to predict and resolve many of the difficult and costly problems due to system level effects early in the product design cycle. SDRC I-DEAS and MSC/NASTRAN, software packages were used for the analysis. Author

A88-50837

TRANSIENT TESTS FOR SPACE STRUCTURES QUALIFICATION

L. P. BUGEAT and M. R. RAZAFIMAHAROLAHY (Intespace, Toulouse, France) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 799-803. Research supported by CNES and Societe Nationale Industrielle Aerospatiale.

The basic principles and implementation of the spacecraft load-identification and dynamic-qualification methods developed at CNES and described by Imbert et al. (1982), Morand et al. (1985), and Girard and Michel (1982) are reviewed. An open-loop approach based on an equivalent-force formulation and impedance coupling is applied in electrodynamic-shaker tests, and the test data are then used to estimate the severe LF loads on the spacecraft at the cutoff of the first and second stage engines of the launcher. Data from tests on the Arabsat structural model are presented in extensive graphs, demonstrating the feasibility of the method. T.K.

A88-50860

EFFECT OF AIR MASS ON MODAL TESTS

JOHN FOWLER, NORMAN LAGERQUIST, and HOWARD LEVE (Hughes Aircraft Co., Space and Communications Group, Los Angeles, CA) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1078-1083.

A 3.2 m 34.7 kg carbon graphite reflector was modal tested in air and in vacuum to assess the effect of air mass. The ability of a mathematical model (NASTRAN) to predict the air mass effect is discussed. The effect of air mass on the fundamental mode shapes is shown to be negligible. K.K.

A88-50863

SPACE STATION DYNAMIC ANALYSIS METHODS

MARY BAKER and PAUL BLELLOCH (SDRC, Inc., San Diego, CA) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1098-1105.

Space Station dynamic characteristics have been studied using realistic Space Station models. With these characteristics as a guide, methods are presented for simultaneously modeling the effects of structural modes, any number of linear continuous time control systems, discrete passive dampers, and spinning bodies. The approach presented includes application of a structural analogy to controls which makes it possible to simulate all the above effects within s single structural dynamics code which is one module of the NASA/SDRC software, IDEAS. Author

A88-50892* Howard Univ., Washington, DC.

FREQUENCY OPTIMIZATION OF REPETITIVE LATTICE BEAM-LIKE STRUCTURES USING A CONTINUUM MODEL

ROBERT REISS (Howard University, Washington, DC) and K. JAYARAMAN IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1565-1572. refs

(Contract NAG1-383)

A new method for obtaining the maximum frequency design of a beam-like repetitive lattice structure is presented. Using existing techniques, the lattice is first modeled as an equivalent anisotropic Timoshenko beam. The computation of the stiffness and inertial properties of the beam, determined by matching the strain and kinetic energies of the beam with those of the lattice, is facilitated by the repetitive nature of the lattice. The optimum design is obtained by maximizing Rayleigh's quotient using methods of variational calculus. For the problem selected, results show excellent agreement with those obtained by traditional finite-element methods. Moreover, unlike FE methods, cpu time is relatively unaffected by the size of the truss. Author

A88-50897

IDENTIFICATION OF MULTIPLE-INPUT MODAL PARAMETERS FROM MULTIPLE-FREQUENCY RESPONSE FUNCTION

RUIYAN LIU (National University of Defense Technology, Changsha, People's Republic of China) and ZIJIE FAN IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1645-1650. refs

In this paper a new concept of multiple frequency response function-MFRF is presented. The identification model of multiple-input modal parameters is established from MFRF, and the calculating formula and process are given. The analytical results of two examples show that the proposed method has the advantages of accuracy, consistency and separating closely-space modes, etc. The method can be used perfectly for experimental modal analysis of large or complicated structures. Author

A88-50899

SPATIAL DISTRIBUTION OF MODEL ERROR BASED ON ANALYTICAL/EXPERIMENTAL FREQUENCY DISCREPANCIES

G. DUDLEY SHEPARD (Lowell, University, MA) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1665-1668. refs

The intent of modal analysis is to develop a reliable dynamic model of a structure by determining and comparing the analytical and experimental modal properties of frequency, damping and mode shape. In addition to identifying these modal properties it would be desirable to determine spatially which parts of the structure are modeled poorly or well. This information could be used to improve the finite element model. It could also point to faults in the structure and hence help to evaluate mechanical integrity. This paper shows how the pattern of discrepancies in the analytical and experimental test values for the pole and zero frequencies of a structure can be linked to discrepancies in the mass or stiffness of the structural elements. Author

A88-50979* Texas Univ., Arlington.

PRECISION POINTING OF SCIENTIFIC INSTRUMENTS ON SPACE STATION: THE LFGGREC PERSPECTIVE

C. C. BLACKWELL (Texas, University, Arlington), S. W. SIRLIN, and R. A. LASKIN (California Insitute of Technology, Jet Propulsion Laboratory, Pasadena) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 566-573. refs

An application of Lyapunov function-gradient-generated robustness-enhancing control (LFGGREC) is explored. The attention is directed to a reduced-complexity representation of the pointing problem presented by the system composed of the Space Infrared Telescope Facility gimbaled to a space station configuration. Uncertainties include disturbance forces applied in the crew compartment area and control moments applied to adjacent scientific payloads (modeled as disturbance moments). Also included are uncertainties in gimbal friction and in the structural component of the system, as reflected in the inertia matrix, the damping matrix, and the stiffness matrix, and the effect of the ignored vibrational dynamics of the structure. The emphasis is on the adaptation of LFGGREC to this particular configuration and on the robustness analysis. I.E.

A88-50980

AEROELASTIC INTERACTIONS WITH FLIGHT CONTROL OF TRANSATMOSPHERIC VEHICLES

ROBERT L. SWAIM (Oklahoma State University, Stillwater) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 574-581. refs

The research needed on structural dynamics interactions with rigid body dynamics and stability augmentation systems to allow confidence in vehicle design are discussed. This includes high-temperature-gradient effects on two- and three-dimensional total-vehicle elastic mode snapes and natural frequencies; robust control laws tolerant of wide uncertainties in elastic mode data; and compatible mathematical models for dynamic analysis of structures exhibiting low-frequency shell-type elastic modes. The expected use of metal matrix and carbon-carbon composite materials and ceramics with internally circulated cooling fluid will greatly complicate proper modeling and analysis of these interactions. I.E.

A88-52238*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

KNOWLEDGE BASED SYSTEM VERIFICATION AND VALIDATION AS RELATED TO AUTOMATION OF SPACE STATION SUBSYSTEMS - RATIONALE FOR A KNOWLEDGE BASED SYSTEM LIFECYCLE

KEITH RICHARDSON and CARLA WONG (NASA, Ames Research Center, Moffett Field, CA) IN: AAAIC '87 - Aerospace Applications of Artificial Intelligence; Proceedings of the Third Annual Conference, Dayton, OH, Oct. 5-9, 1987. Dayton, OH, AAAIC Conference Secretariat, 1988, p. 306-311. Previously announced in STAR as N88-24192.

The role of verification and validation (V and V) in software has been to support and strengthen the software lifecycle and to ensure that the resultant code meets the standards of the requirements documents. Knowledge-based system (KBS) V and V should serve the same role, but the KBS lifecycle is ill-defined. The rationale of a simple form of the KBS lifecycle is presented, including accommodation to certain critical KBS differences from software development. Author

A88-52355

REAL-TIME FAULT MANAGEMENT FOR LARGE-SCALE SYSTEMS

H. BIGLARI (Boeing Aerospace Co., Huntsville, AL), C. CHENG, and G. VACHTSEVANOS (Georgia Institute of Technology, Atlanta) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 9-63 to 9-69. refs

A priori knowledge of failure modes of a system is an indispensable information for design of robust decentralized hierarchical control schemes. In particular inclusion of system faults as part of the process under control provides greater flexibility for self diagnosis and maintenance of real-time systems. By assigning discrete states to the process under control, an 'artificial consciousness' can be created within the controller which allows the controller to exercise selective actions for each given discrete state. This concept has been implemented to control the utility systems of the Space Station Laboratory Simulator. Author

A88-52639

DYNAMICS ANALYSIS OF A SYSTEM OF HINGE-CONNECTED FLEXIBLE BODIES

MADELEINE PASCAL (Paris VI, Universite, France) Celestial Mechanics (ISSN 0008-8714), vol. 41, no. 1-4, 1987/88, p. 253-274. Research supported by Matra Espace. refs

The subject of this work is the dynamics of flexible space vehicles modeled by a chain of rigid and elastic bodies with tree structure. The aim is to obtain an impedance matrix giving (in the frequency domain) the response of the structure to external forces. It is possible to obtain an expansion of this impedance matrix in terms of an infinite set of modal frequencies (termed constrained modes) and an expansion of the inverse of this impedance matrix in terms of another set of modes. The work is a generalization of the theory of Hugues (1974) and others for systems with star structure. Author

A88-53420

LOAD DEPENDENT SUBSPACE REDUCTION METHODS FOR STRUCTURAL DYNAMIC COMPUTATIONS

PIERRE LEGER (McGill University, Montreal, Canada) Computers and Structures (ISSN 0045-7949), vol. 29, no. 6, 1988, p. 993-999. refs

The evaluation of the dynamic response analysis of large structures by vector superposition requires in its traditional formulation the solution of a large and expensive eigenvalue problem. A new method of dynamic analysis using load-dependent transformation vectors for systems subjected to fixed spatial distribution of dynamic loads was introduced by Wilson et al. (1982) as an economic alternative to the usual mode-superposition method. Here, new computational variants to generate a load-dependent transformation basis for arbitrary transient loading which are a function of space and time are presented. Numerical applications on a simple structural system are used to show the relative efficiency of the proposed solution procedure over classical solution methods using mode-displacement, mode-acceleration, or the original (fixed) load-dependent reduction method. Author

A88-53681

LABORATORY FACILITY FOR FLEXIBLE STRUCTURE CONTROL EXPERIMENTS

UMIT OZGUNER, STEPHEN YURKOVICH (Ohio State University, Columbus), JOSEPH W. MARTIN, and PAUL T. KOTNIK (Battelle Memorial Institute, Columbus, OH) (Virginia Polytechnic Institute and State University and AIAA, Symposium on Dynamics and Control of Large Space Structures, 6th, Blacksburg, VA, June 1987) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 8, Aug. 1988, p. 27-33. Research supported by the Digital Equipment Corp. refs

(Contract NSF DMC-85-06143)

A laboratory facility to study various control problems related to flexible mechanical structures is described. Computer, interfacing, and software issues are discussed. A novel proof-mass actuator is presented. A free-free suspended-beam experiment and a skewing-beam experiment are described. Three additional experimental setups at various stages of development are briefly considered. I.E.

A88-53785

NECESSARY CONDITIONS OF GEOMETRICAL STABILITY IN TRUSSES WHICH INCLUDE ONE-FORCE MEMBERS

CARL C. VON STETTEN (Stubbins Associates, Inc., Cambridge, MA) SAWE, Annual Conference, 46th, Seattle, WA, May 18-20, 1987. 26 p. refs
(SAWE PAPER 1776)

Trusses may include three distinct types of members: either compressionally or tensionally stressed one-force members, and two-force members that bear stresses both compressionally and tensionally. Attention is presently given to the nature of those conditions which, according to both theoretical and pragmatic criteria, are more advantageous when trusses are allowed to include one-force members rather than two-force members exclusively. It is found that many systems of joints can be stabilized entirely with one-force members, with negligible effect on the number of members required. O.C.

A88-53945

SPATIAL EVOLUTION OF THE RESIDUAL-ACCELERATION VECTOR ON BOARD SPACECRAFT [PROSTRANSTVENNAIA EVOLIUTSIIA VEKTORA OSTATOCHNYKH USKORENII NA BORTU KOSMICHESKIKH APPARATOV]

V. S. AVDUEVSKII, A. I. LIKHODED, V. V. SAVICHEV, V. B. DUBOVSKOI, S. S. OBYDENNIKOV et al. Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 26, July-Aug. 1988, p. 621-625. In Russian. refs

Levels of small residual accelerations were measured on Salyut 6 and 7, the Progress transport vehicle, and a number of Mir rockets. The results indicate that the conditions necessary for space manufacturing operations on board spacecraft are characterized not only by a reduction in mass forces and accelerations but also by the variable character of these forces and accelerations in time and space. The data obtained were used to assess the possibility of prolonging the service life of Salyut-6. B.J.

A88-54401

1988 AMERICAN CONTROL CONFERENCE, 7TH, ATLANTA, GA, JUNE 15-17, 1988, PROCEEDINGS. VOLUMES 1, 2, & 3

Conference sponsored by the American Automatic Control Council. New York, Institute of Electrical and Electronics Engineers, 1988, p. Vol. 1, 863 p.; vol. 2, 919 p.; vol. 3, 841 p. For individual items see A88-54402 to A88-54676.

Various papers on control are presented. The general topics considered include: simulation and computational methods; linear systems and control; control of flexible structures; intelligent control systems; industrial control systems; computer-aided control engineering; robust adaptive control; frequency-domain methods; filtering, estimation, and tracking; optimization of discrete event systems; trajectory control of robot manipulators; digital signal processsing in process control; control of batch processes; robustness of state space models; stable factorization; aircraft and spacecraft guidance; model order reduction; computer networking of real-time control; and advances in automatic control education. Also addressed are: implementation of adaptive and self-tuning controls in machining, eigenvalue/eigenstructure assignment, robust nonlinear control of manipulators, redundant robot control, fault detection, ACES control theory and verification, decentralized control, damage-tolerant flight control systems, neural networks in control, distributed parameter and time-delay systems, and robust stabilization and control. C.D.

A88-54406

THE JITTER BEAM - AN EXPERIMENT DEMONSTRATING POINTING CONTROL ON A FLEXIBLE STRUCTURE

ERIC K. PARSONS (Lockheed Research Laboratories, Palo Alto, CA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 61-68. refs

An experiment called the jitter beam simulates the interaction of a pointing control system and a flexible structure. Noncolocation of a sensor and an actuator makes control difficult. A linear quadratic Gaussian (LQG) design overcomes the noncolocation problem by use of a bending model, allowing the jitter-beam control to coordinate, with a single torquer, the motions of several points on the structure to achieve the pointing goal. A control bandwidth two times higher than a critical bending frequency is obtained, a factor of ten beyond what a rigid-body design can achieve. The jitter beam experiment resembles small stiff structures like active mirrors, although the control methodology can be extended to large structures and complex systems. The sparse model frequency spectrum of stiff structures simplifies identification, but because bending frequencies are high, sensor noise, actuator saturation, and computational speed constrain performance. In contrast, the low frequencies of large structures make hardware constraints a small concern, but the dense frequency distribution complicates system identification. I.E.

A88-54410

PROJECTIVE CONTROLS FOR DISTURBANCE ATTENUATION IN LSS SYSTEMS

R. A. RAMAKER, J. MEDANIC, and W. R. PERKINS (Illinois, University, Urbana) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 89-94. refs
(Contract N00014-84-C-0149)

A design methodology is presented which addresses three main issues in the control of large space structures: improving the disturbance attenuation of the system, implementing the design as a low-order output feedback controller, and ensuring that the controller is robust to modeling uncertainty. The method developed to solve this problem makes use of projective controls. A frequency-domain characterization of the disturbance attenuation properties of projective controllers is developed to use design freedoms in the controllers to achieve robust disturbance attenuation. A 20-mode example demonstrates the use of this methodology. I.E.

A88-54421

USE OF ASSUMED MODES IN EQUATIONS GOVERNING LARGE-DISPLACEMENT ELASTODYNAMIC PLATE BEHAVIOR

R. R. RYAN, R. A. SCOTT (Michigan, University, Ann Arbor), and H. H. YOO IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 170-176. Research supported by Mechanical Dynamics, Inc. refs

The dynamic behavior of multibody systems containing structural elements undergoing large overall rotation and translation as well as small elastic deformations is considered. A systematic procedure, using assumed mode functions and von Karman-type strain measures, is developed to properly account for motion-induced structural stiffness variations during arbitrary overall motion. The procedure is compared in terms of accuracy and efficiency with recently developed imbedded geometric constraint methods involving linear strain-displacement relationships and with more conventional multibody techniques. A numerical example involving a simple supported plate attached to a rigid body (floating frame) undergoing a prescribed large-displacement motion is presented. Extensions to complex multibody systems containing various element types are discussed. I.E.

A88-54423

IMPROVED METHODS FOR LINEARIZED FLEXIBILITY MODELS IN MULTIBODY DYNAMICS AND CONTROL

R. JONES, W. CIMINO, and W. RUSSELL (Boeing Aerospace Co., Seattle, WA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 189-194. refs

Simulation of structural response of multi-flexible-body systems by linearized flexible motion combined with nonlinear rigid motion is discussed. The advantages and applicability of such an approach for accurate simulation with reduced computational costs and turnaround times are briefly described, restricting attention to a control design environment. Requirements for updating the linearized flexibility model to track large angular motions are discussed, several update approaches are compared, and an approach that improves on previously published methods is recommended. A simple system undergoing large rotations is used for numerical illustration. I.E.

A88-54471* Honeywell, Inc., Clearwater, FL.

OBSTACLES TO HIGH FIDELITY MULTIBODY DYNAMICS SIMULATION

K. W. LIPS (Honeywell, Inc., Space and Strategic Avionics Div., Clearwater, FL) and R. P. SINGH (DYNACS Engineering Co., Inc., Clearwater, FL) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 587-594. refs
(Contract NAS8-34588)

The authors take a wide ranging look at issues involved in the dynamic modeling of complex, multibodied orbiting space systems. The nature of the multibody problem is reviewed and capabilities and limitations of two major codes (DISCOS, TREETOPS) are assessed. Problem areas that limit accuracy or contribute to uncertainty in the modeling, simulation process are identified. As a specific case, the significance of including, or of not including, second-degree geometric nonlinearity in the elastic displacement field (foreshortening) is evaluated. Conclusions and recommendations are made concerning the direction future development should take to achieve higher-fidelity and more computationally efficient multibody software solutions. I.E.

A88-54532* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

RAPID MULTI-FLEXIBLE-BODY MANEUVERING EXPERIMENTS

JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1009-1014. refs

Progress at the NASA Langley Research Center in the area of rapid multiple-flexible-body maneuvering experiments is described. The experiments are designed to verify theoretical analyses using control theory for the control of flexible structures. The objective of the maneuvering experiments is to demonstrate slewing of flexible structures in multiple axes while simultaneously suppressing vibration to have acceptable motion at the end of the maneuver. The status of some research activities oriented primarily to the experimental methods for control of flexible structures is presented. I.E.

A88-54533

DEVELOPMENT OF A CONTROL ORIENTED MODEL OF A CANTILEVERED BEAM WITH END-MASS

UMIT OZGUNER and ERIC BREITFELLER (Ohio State University, Columbus) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1015-1020. USAF-supported research.

A cantilevered beam configuration with a disk at the end is considered. Active vibration damping is to be accomplished with two sets of double proof-mass actuators mounted on the disk. A mathematical model is developed for control studies, based on a combination of analytical modeling of both the structure and the actuators, with experimental validation and adjustment. I.E.

A88-54572* Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.

ADVANCED CONTROL EVALUATION FOR STRUCTURES (ACES) PROGRAMS

JEROME PEARSON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and HENRY WAITES (NASA, Marshall Space Flight Center, Huntsville, AL) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1448-1452.

The ACES programs are a series of past, present, and future activities at the Marshall Space Flight Center (MSFC) Ground facility for Large Space Structure Control Verification (GF/LSSCV). The main objectives of the ACES programs are to implement control techniques on a series of complex dynamical systems, to determine the control/structure interaction for the control techniques, and to provide a national facility in which dynamics and control verification can be effected. The focus is on these objectives and how they are implemented under various engineering and economic constraints. Future plans that will be effected in upcoming ACES programs are considered. I.E.

A88-54574

APPLICATION OF FAMESS TO A LARGE SPACE STRUCTURE GROUND TEST FACILITY

R. DENNIS IRWIN (Ohio University, Athens) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1456-1461.

Filter accommodated model error sensitivity suppression (FAMESS) is applied to the problem of regulating the line-of-sight (LOS) of a laser beam pointing system mounted on a 13-m flexible beam, which is the current configuration of the Marshall Space Flight Center Large Space Structure Ground Test Verification Facility (LSS/GTV). The configuration of the LSS/GTV exhibits many of the pathologies usually associated with large space structures (LSS). The collection of techniques commonly known as FAMESS is used to accomplish the design of the LOS regulating control system for the LSS/GTV. These techniques include decentralization, alpha shifting techniques, model error sensitivity suppression, and filter accommodation. Representative test results are presented and illustrate the dramatic degradation of performance which can be expected when significant system behavior is unmodeled. I.E.

A88-54575

EXPERIMENTAL DEMONSTRATION OF THE MAXIMUM ENTROPY/OPTIMAL PROJECTION DESIGN THEORY FOR ACTIVE VIBRATION CONTROL

S. W. GREELEY, D. J. PHILLIPS, and D. C. HYLAND (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1462-1467. refs

Based on a recent survey of large space system concepts and the identified characteristics of ground-based experiments needed to demonstrate capability for future systems, a sequence of vibration control experiments has been designed. The experiments involve a progression of structural configurations ranging from relatively simple one- and two-dimensional structures to a large aperture, multisegment optical structure. The experiments have been designed to evaluate a variety of control design methods, including the maximum entropy/optimal projection method. The concepts and status of these experimental activities are reviewed. I.E.

A88-54576

RECENT RESULTS IN IDENTIFICATION AND CONTROL OF A FLEXIBLE TRUSS STRUCTURE

R. LANE DAILEY and MICHAEL S. LUKICH (TRW, Inc., Redondo Beach, CA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1468-1473. refs

Results are presented from an ongoing laboratory experiment in identification and feedback control of TRW's flexible truss structure. H(infinity) and mu-synthesis design methods were used to design high-performance MIMO (multi-input, multioutput) digital control laws for the six-input, four-output system. Noncollated feedback has reduced RMS structural vibration (as measured by the four sensors) by a factor of 48:1 open-loop versus closed-loop

(60:1 on specific outputs). Frequency domain system identification, using FFT (first Fourier transform) transfer function measurements and a Chebyshev polynomial curve fitting method, was the crucial factor in achieving these high performance levels. I.E.

A88-54577

IDENTIFICATION OF A FLEXIBLE TRUSS STRUCTURE USING LATTICE FILTERS

MARIBETH D. ROESLER, MICHAEL S. LUKICH (TRW, Inc., Control Systems Engineering Dept., Redondo Beach, CA), FARYAR JABBARI (California, University, Irvine), and J. S. GIBSON (California, University, Los Angeles) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1474-1482. refs

The size and complexity of next-generation space structures present a formidable challenge for online (adaptive) identification methods. The methods must accommodate a variety of structural changes resulting from on-orbit assembly, spacecraft docking, and time-varying disturbance, which affect the order of the structural system's model. TRW's flexible truss structure was used to demonstrate the feasibility of the least-squares lattice filter for the identification of both a time-invariant and a time-varying system. The results, including natural frequency estimates, frequency responses, and one-step-ahead predictions, show that the lattice filters provide accurate and timely estimates for the different configurations considered, in particular for a two-input two-output plant and a time-varying system. I.E.

A88-54583

APPLICATION OF INCLUSION PRINCIPLE TO MECHANICAL SYSTEMS

AJMAL YOUSUFF (Drexel University, Philadelphia, PA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1516-1520. Research supported by Drexel University.
(Contract NSF INT-86-12195)

As an attempt to simplify the decentralized control design methodology, the inclusion principle of Ikeda and Siljak (1980) is specifically applied to mechanical systems. It is shown that an expanded system can be obtained, in a matrix second-order form, which includes the original system. Sufficient conditions and transforms of the system matrices are given to guarantee that the original system would be either an aggregation, or a restriction, of the resulting expanded system. A constructive procedure is provided to produce an expanded system which is the best approximation (in a 2-norm sense) of a prespecified structure/dynamics of the expanded system. An example illustrates the methodology. I.E.

A88-54587* National Taiwan Univ., Taipei.

DECENTRALIZED MODEL REFERENCE ADAPTIVE CONTROL OF LARGE FLEXIBLE STRUCTURES

FU-MING LEE, I-KONG FONG (National Taiwan University, Taipei, Republic of China), and YU-HWAN LIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1538-1543. Sponsorship: National Science Council of the Republic of China. refs
(Contract NSC-77-0404-E002-28)

A decentralized model reference adaptive control (DMRAC) method is developed for large flexible structures (LFS). The development follows that of a centralized model reference adaptive control for LFS that have been shown to be feasible. The proposed method is illustrated using a simply supported beam with collocated actuators and sensors. Results show that the DMRAC can achieve either output regulation or output tracking with adequate convergence, provided the reference model inputs and their time derivatives are integrable, bounded, and approach zero as t approaches infinity. I.E.

A88-54630

LOW AUTHORITY CONTROL OF A COMPOSITE CANTILEVER BEAM IN TWO DIMENSIONS

JOHN A. CONNALLY and JAMES E. HUBBARD, JR. (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1903-1908. refs

The authors present theoretical and experimental results on active vibration control of a cantilevered S-glass composite beam using polyvinylidene (PVF2) film as a low-authority distributed control actuator. The beam is approximately 0.25 x 0.25 x 12 inches with a small mass mounted at the free end. The Liapunov stability criterion is used to derive a control algorithm for the active damper based on angular rate feedback of the free end of the beam. The algorithm is stable for all vibrational modes of the beam. Experimental results are presented which show the increase in damping produced by the PVF2 actuators for the first two modes of vibration of the beam. The damping ratio for the first mode was increased from 0.2061 to 0.6588, and the increase for the second mode was from 0.1402 to 0.5432 (with the electromagnetic excitation source oriented in the +y direction) I.E.

A88-54639

H(INFINITY) ROBUST CONTROL SYNTHESIS FOR A LARGE SPACE STRUCTURE

M. G. SAFONOV, R. Y. CHIANG, and H. FLASHNER (Southern California, University, Los Angeles, CA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 2038-2045. Research supported by TRW, Inc. refs

In a design study involving the use of H(infinity) optimal control theory, an 11-state control law is generated for a 116-state model of a large flexible space structure. A combination of colocated rate feedback, modal truncation, and optimal Hankel-norm model techniques is found to lead to a vastly simplified four-state model for the structure which, by singular-value theory, is proved to be satisfactory for design of a controller whose bandwidth exceeds the natural frequencies of all of the modes of the original 116-state model. Specifications regarding disturbance attenuation, bandwidth, and stability robustness are quantitatively expressed as weighting functions in a mixed-sensitivity H(infinity) optimal-control synthesis problem, the solution to which is computed using the LINF program of Chiang and Safonov (1987). I.E.

A88-54640

A ROBUST CONTROL EXPERIMENT USING AN OPTICAL STRUCTURE PROTOTYPE

DAVID C. HYLAND and EMMANUEL G. COLLINS, JR. (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 2046-2049. refs

A robust control experiment, called the Multi-Hex Prototype (MHP) experiment, currently in progress is described. A detailed physical description of the experiment's physical apparatus is presented. Sources of modeling error are discussed. A brief description of the approaches to be used for robust control system design and analysis is given. I.E.

A88-54643

A FOURIER-BASED OPTIMAL CONTROL APPROACH FOR STRUCTURAL SYSTEMS

VINCENT YEN and MARK L. NAGURKA (Carnegie-Mellon University, Pittsburgh, PA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 2082-2087.

The authors consider the optimal control of structural systems with quadratic performance indices. The proposed approach approximates each configuration variable of a structural model by the sum of a fifth-order polynomial and a finite-term Fourier-type series. In contrast to standard linear optimal control approaches which typically require the solution of Riccati equations, the method adopted is a near-optimal approach in which the necessary and sufficient condition of optimality is derived as a system of linear algebraic equations. These equations can be solved directly by a method such as Gaussian elimination. The proposed approach is computationally efficient and can be applied to structural systems of high dimension and/or to structural systems with fixed (or highly penalized) terminal states without numerical difficulties. I.E.

A88-54655

VARIABLE STRUCTURE CONTROL OF DECOUPLEABLE SYSTEMS AND ATTITUDE CONTROL OF SPACECRAFT IN PRESENCE OF UNCERTAINTY

ASHOK IYER and SAHJENDRA N. SINGH (Nevada, University, Las Vegas) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 2238-2243. refs

(Contract DAAL03-87-G-0004)

The authors consider control of a class of uncertain nonlinear systems which can be decoupled by state-variable feedback. A variable-structure control (VSC) law is derived such that in the closed-loop system the output variable asymptotically tracks a given output trajectory in spite of uncertainty in the system. Based on this result, a control law is derived for the attitude control of an orbiting spacecraft in the presence of uncertainty using reaction jets. The controlled outputs are the three Euler angles which describe the orientation of the spacecraft relative to an orbital frame. Simulation results are presented to show that in the closed-loop system precise attitude control is accomplished in spite of the uncertainty in the system. I.E.

A88-54973#

OPTIMIZATION OF ACTIVELY CONTROLLED STRUCTURES USING MULTIOBJECTIVE PROGRAMMING TECHNIQUES

SINGIRESU S. RAO (Purdue University, West Lafayette, IN) IN: Developments in Mechanics. Volume 14(c) - Midwestern Mechanics Conference, 20th, West Lafayette, IN, Aug. 31-Sept. 2, 1987, Proceedings. West Lafayette, IN, Purdue University, 1987, p. 1215-1221. refs

The design of minimum weight structures with constraints on the damping parameters of the closed loop system in the design of an active control system is considered using multiobjective optimization techniques. The cross sectional areas of the members are treated as design variables. The structural weight and the controlled system energy are considered as objective functions for minimization. The goal programming and game theory approaches are used for the solution of the multiobjective optimization problems. The feasibility of the approaches is demonstrated through the design of two-bar and twelve-bar truss structures. Author

A88-54989#

TRANSFER MATRIX ANALYSIS OF CABLE-STIFFENED HOOP PLATFORMS

R. G. LOEWY (Rensselaer Polytechnic Institute, Troy, NY) and C. L. ZARETZKY Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, Jan.-Feb. 1988, p. 45-52. refs

(Contract AF-AFOSR-83-0348)

A transfer matrix methd is applied to the free-vibration analysis of a series of cable-stiffened hoop platforms, which are often encountered as subassemblies in large space antennas. The method takes advantage of the cyclic symmetry of the structures to reduce significantly the amount of computations necessary to determine natural frequencies and the associated mode shapes. Numerical difficulties, which often arise in transfer matrix analyses of periodic structures, are not encountered with the method presented. Free-vibration characteristics are calculated for equilateral hoop assemblies with from 5 to 11 segments. Properties are chosen to allow comparison with the earlier experiments and calculations of Belvin, and good agreement is shown for that specific, hexagonal hoop platform. Running time comparisons indicate that the transfer matrix approach provides a promising alternative to finite-element methods for the dynamic analysis of spacecraft structures characterized by slender substructures and repetitive geometry. Author

A88-55062#

ADVANTAGES OF TETHER RELEASE OF SATELLITES FROM ELLIPTIC ORBITS

GEORGE A. KYROUDIS (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) and BRUCE A. CONWAY (Illinois, University, Urbana) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Sept.-Oct. 1988, p. 441-448. Previously cited in issue 23, p. 3421, Accession no. A86-47944. refs

A88-55063#

THEORETICAL AND EXPERIMENTAL INVESTIGATION OF SPACE-REALIZABLE INERTIAL ACTUATION FOR PASSIVE AND ACTIVE STRUCTURAL CONTROL

DAVID W. MILLER and EDWARD F. CRAWLEY (MIT, Cambridge MA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Sept.-Oct. 1988, p. 449-458. refs

(Contract F49620-84-K-0010)

Inertial reaction devices are investigated for use as passive vibration absorbers and active control actuators for flexible space structures. Absorbers are designed for one- and two-degree-of-freedom structural representations using three parameter optimization techniques. All three yield nearly identical designs and indicate that inertial devices should be tuned to the lowest mode intended to receive increased damping. The optimal passive components of the control actuator are found to be those of the optimal passive vibration absorber. Proof-of-concept laboratory tests were performed on a quasi-free-free beam using inertial reaction devices that are space-realizable, i.e., conceptually capable of functioning in the space environment. The inertial devices were used as both passive absorbers and tuned actuators. Damping was significantly increased using both passive and passive/active techniques. Additional tests indicated the benefits and limitations of actuator tuning and the necessity of performing realistic experiments using space-realizable hardware. Author

A88-55067#

TETHERED SUBSATELLITE SWINGING FROM ATMOSPHERIC GRADIENTS

JUNJIRO ONODA and NAOYUKI WATANABE (Tokyo, University, Japan) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Sept.-Oct. 1988, p. 477-479.

The mechanism responsible for the instability described by Yuhara et al. (1986) in the in-plane motion of a tethered satellite in LEO is investigated analytically. The equations of motion are derived with a series of simplifying assumptions and linearized; a stability analysis is performed; and numerical results for a 500-kg satellite with drag coefficient 2.2 and projected drag area 10 sq m (including the tether) deployed at altitude 115 km are presented in tables. The instability is shown to result from the action of atmospheric density gradients, with the unstable region depending on the longitudinal rigidity of the tether and the atmospheric drag. T.K.

A88-55088*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SINE DWELL OR BROADBAND METHODS FOR MODAL TESTING

JAY-CHUNG CHEN and BEN K. WADA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B, p. 998-1004) AIAA Journal (ISSN 0001-1452), vol. 26, June 1988, p. 733-737. Previously cited in issue 14, p. 2113, Accession no. A87-33752. refs

A88-55371#

CONTROL OF LARGE SPACE STRUCTURES USING REDUCED ORDER MODELS

JAYANT V. RAMAKRISHNAN (Dynacs Engineering Co., Inc., Clearwater, FL), S. VITTAL RAO, and LESLIE R. KOVAL (Missouri-Rolla, University, Rolla) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 11 p. refs
(IAF PAPER 88-272)

Two reduced-order system modeling methods, the balanced-realization method and the multivariable Routh method, are considered in the context of the control of large space structures via reduced-order controllers. Results of simulations are presented to demonstrate that controllers based on reduced-order models provide efficient control performance, with good correlation between suboptimal and optimal responses. It is noted, however, that the method of model reduction is often problem dependent and that some methods may be more amenable than others for a class of problems. V.L.

A88-55375*# Howard Univ., Washington, DC.

EFFECT OF NATURAL DAMPING ON THE DYNAMICS AND CONTROL OF A CLASS OF OPTIMALLY DESIGNED STRUCTURES

K. SATYANARAYANA and M. BAINUM (Howard University, Washington, DC) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 10 p. Research supported by Howard University and NASA. refs
(IAF PAPER 88-288)

In this study the vibration control of large space structures with structural damping is investigated. Emphasis is made on the control of both a class of optimally designed (stepped) structures and also the corresponding uniform structures using a cantilever beam as an example. The open loop and closed loop dynamics are compared and the transient responses are determined to study the effect of damping on the control system design. Author

A88-55377#

STABILITY OF IMPERFECTION-SENSITIVE NONLINEAR SPACE STRUCTURES UNDER STOCHASTIC LOADING

T. S. SANKAR (Concordia University, Montreal, Canada) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p. refs
(Contract NSERC-A-7104)
(IAF PAPER 88-293)

Nonlinear space structures and components subjected to stochastic loading are analyzed by using a quasi-stationary solution to the governing nonlinear stochastic differential equations in phase space to obtain the probability density of the first instability of the system in a specified time of operation. The random loading is modeled as a delta-correlated excitation with a wideband spectra, and the resulting dynamic response is approximated by a Markov process with known initial conditions corresponding to a stable equilibrium state. An expression for the failure probability is derived, and conditions for its validity are defined. V.L.

A88-55378#

GENERIC MODEL LABORATORY TESTS FOR LARGE FLEXIBLE STRUCTURE CONTROL

THOMAS LANGE (DFVLR, Wessling, Federal Republic of Germany) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 8 p.
(IAF PAPER 88-294)

A generic model testing concept for large flexible structures is developed which involves a two-stage test procedure based on the 'ideal' and 'realistic' approaches. The 'ideal' test approach addresses the fundamental problems of structural dynamics vs. control interaction, with hardware imperfections excluded as far as possible. The 'realistic' approach covers unpredicted hardware constraints interfering with the overall system dynamics and is implemented in software in a real-time processor in addition to external filtering and noise suppression. Based on results obtained for a hanging plate, it is suggested that a systematic sequence of tests be developed which approaches, step by step, the expected generic features of large space structures. V.L.

A88-55386#

OPTIMAL DEPLOYMENT OF SPACECRAFT APPENDAGES

A. K. MISRA (McGill University, Montreal, Canada) and S. KALAYCIOGLU IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p. refs
(IAF PAPER 88-307)

The existing dynamical analyses of axially moving beams assume a given deployment scheme (usually, uniform deployment rate) and determine the corresponding vibratory response. The present paper, however, attempts to determine deployment schemes so that the vibrations during deployment are minimized. The minimization is carried out using Pontriagin's principle. In this, deployment of a beam-type appendage from a given initial length to a desired final length within a specified duration of time is considered and the square of the displacement, integrated over the length and over the given duration, is minimized. The two point boundary value problem obtained is solved numerically. The vibration during this optimum deployment scheme is much smaller than that during uniform or exponential deployment. Author

A88-55391#

DYNAMICS OF INTERCONNECTED FLEXIBLE MEMBERS IN THE PRESENCE OF ENVIRONMENTAL FORCES - A FORMULATION WITH APPLICATIONS

V. J. MODI and A. C. NG (British Columbia, University, Vancouver, Canada) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 10 p. refs
(Contract NSERC-G-1547)
(IAF PAPER 88-318)

A relatively general formulation for studying the dynamics of spacecraft with interconnected flexible bodies is presented accounting for thermal deformations and transverse vibrations of the structural members. In addition, the shift in the center of mass of the system and the slewing maneuvers of the members are incorporated. The formulation can be applied to study the U.S. proposed Space Station as well as a large class of present and future spacecraft. An example illustrates application of the formulation. The model under study is a satellite with a central rigid body and a pair of appendages. The satellite response is investigated numerically over a range of system parameters and effect of the thermal deformations assessed. An approximate closed-form (analytical) solution of the problem is also obtained to quickly assess trends and gain better physical appreciation of response characteristics. Author

A88-55393*# Howard Univ., Washington, DC.

RAPID SLEWING OF THE ORBITING SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE) USING LQR TECHNIQUES

CHEICK M. DIARRA and PETER M. BAINUM (Howard University, Washington, DC) IAF, International Astronautical Congress, 39th Bangalore, India, Oct. 8-15, 1988. 9 p. refs
(Contract NSG-1414)
(IAF PAPER 88-320)

The rotational equations of motion, describing the dynamics of the (rigidized) proposed orbiting Spacecraft Control Laboratory Experiment (SCOLE) during the station keeping phase, are derived using the Eulerian formulation. When the attitude angles (roll, pitch, and yaw) are assumed small, a stability analysis is conducted for the system. It is seen that the pitch equation decouples from the roll and yaw equations when the interface between the mast on the reflector is not offset or the offset is only along the Shuttle roll axis. When a second offset is introduced along the pitch axis of the system and when the gravity-gradient torques are present in the dynamics, the system assumes a new equilibrium position. The linear regulator theory is used to derive a control law for the linear model of the rigidized SCOLE. This law is applied to the nonlinear model of the same configuration of the system and preliminary single axis slewing maneuvers (20 deg amplitude) are simulated. Author

A88-55397#
THE SYSTEM OF THE MIR STATION MOTION CONTROL
V. N. BRANETS, V. P. LEGOSTAEV, and B. E. CHERTOK IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 9 p.
(IAF PAPER 88-334)

The motion control and navigation system (MCNS) of the Mir station are examined. The tasks of the MCNS are presented, including orientation, control relative to the center of mass, navigation and stabilization. The structure, composition, and operating modes of the MCNS are discussed. In addition, the sensing elements, digital computer complex, and reliability support of the Mir station are described. R.B.

N88-20290*# California Univ., Los Angeles. Dept. of Engineering and Applied Science.
CONTROL AUGMENTED STRUCTURAL SYNTHESIS
ROBERT V. LUST and LUCIEN A. SCHMIT Washington NASA Apr. 1988 193 p
(Contract NSG-1490)
(NASA-CR-4132; NAS 1.26:4132) Avail: NTIS HC A09/MF A01 CSCL 01C

A methodology for control augmented structural synthesis is proposed for a class of structures which can be modeled as an assemblage of frame and/or truss elements. It is assumed that both the plant (structure) and the active control system dynamics can be adequately represented with a linear model. The structural sizing variables, active control system feedback gains and nonstructural lumped masses are treated simultaneously as independent design variables. Design constraints are imposed on static and dynamic displacements, static stresses, actuator forces and natural frequencies to ensure acceptable system behavior. Multiple static and dynamic loading conditions are considered. Side constraints imposed on the design variables protect against the generation of unrealizable designs. While the proposed approach is fundamentally more general, here the methodology is developed and demonstrated for the case where: (1) the dynamic loading is harmonic and thus the steady state response is of primary interest; (2) direct output feedback is used for the control system model; and (3) the actuators and sensors are collocated. Author

N88-20348# Groningen Rijksuniversiteit (Netherlands). Systems and Control Group.
SIMSAT: SIMULATION PACKAGE FOR FLEXIBLE SYSTEMS. BEAMS IN SPACE M.S. Thesis
MARTIN H. KLOMPSTRA Apr. 1987 61 p
(TW-278; ETN-88-91868) Avail: NTIS HC A04/MF A01

A simulation package (SIMSAT) for flexible systems was developed to study the effects of flexibility, damping, and stabilizing (robust) compensators on these systems. Three partial differential equation models for flexible systems are simulated: Euler-Bernoulli beam with structural damping; Euler-Bernoulli beam with viscous damping, and two Euler-Bernoulli beams with viscous damping connected through a central disk. Possible simulations include simulate the models with or without damping, or connect a compensator to the models (closed loop systems). The SIMSAT calculates the state-evolution w(x,t) of the system, and the input, output, energy, and mean square error corresponding to these. All these calculations can either be shown in numbers (numerical results) or in curves. For the state-evolution two extra graphical facilities are present namely a motion picture and a three dimensional curve. If desired these numerical results and curves can be sent to a printer. The package was developed in Turbo-Pascal for a personal computer with MS-DOS. ESA

N88-20349# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
UTILIZATION OF STRAPDOWN INERTIAL AND NON-INERTIAL SENSORS IN DETERMINATION OF SATELLITE ATTITUDE BY KALMAN FILTERS M.S. Thesis [UTILIZACAO CONJUNTA DE SENSORES INERCIAIS E NAOINERCIAIS EM DETERMINACAO DE ATITUDE DE SATELITES VIA FILTRO DE KALMAN]
VALTAIR ANTONIO FERRARESI Aug. 1987 129 p In PORTUGUESE; ENGLISH summary
(INPE-4313-TDL/280) Avail: NTIS HC A07/MF A01

Four procedures utilizing inertial sensors (gyrometers) and non-inertial sensors (sun and horizon sensors) in the attitude determination of low-orbit artificial satellites are compared. The parameterized state estimation in quaternion is made through the Extended Kalman Filter. The use of the quaternion as state parameterization results in some problems in Kalman Filter application. These problems are due to the error covariance matrix singularity in the parameterized state, which is a difficult condition to be maintained numerically. Four procedures that avoid this difficulty are analyzed. Performance comparison and analysis of these procedures are made through digital simulation. Author

N88-20902# Lawrence Livermore National Lab., CA.
ROBUST DECENTRALIZED CONTROL OF LARGE FLEXIBLE STRUCTURES
S. C. LU, I. K. FONG, S. H. WANG, and S. BUMPUS 17 Nov. 1987 48 p Prepared in cooperation with California Univ., Davis.
(Contract W-7405-ENG-48)
(DE88-005416; UCRL-15980) Avail: NTIS HC A03/MF A01

This report studies the problem of controlling a large flexible structure with robust decentralized feedback control. A decentralized optimal control algorithm is applied to compute the parameters of the robust controller. The proposed method is tested on the ACOSS Model No. 2, which is a realistic evaluation model for active structure control methods. Twelve co-located sensors and actuators are applied in order to suppress vibrations which are caused by two external disturbances. It is demonstrated that the proposed method can stabilize the closed-loop system via decentralized feedback. Other performance measures are also discussed. DOE

N88-21200# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).
NUMERICAL SOLUTION OF MULTIBODY SYSTEMS IN SPACE APPLICATIONS
B. SPECHT *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 59-63 Dec. 1987
Avail: NTIS HC A14/MF A01

A numerical analysis tool for 3D mechanical multibody systems is presented. The method is based on Lagrange's equation with constraints which are enforced by the Lagrange multiplier technique. Kinematic, static, and dynamic analysis modes are available. The in orbit deployment of a large parabolic antenna reflector was simulated. The CPU times for kinematic, quasi-static, and dynamic modes are 7.2, 21, and 32 min respectively on a VAX-750. ESA

N88-21230# Teldix Luftfahrt-Ausruestungs G.m.b.H., Heidelberg (Germany, F.R.).
EVOLUTION OF LARGE MOMENTUM AND REACTION WHEELS
H. HEIMEL *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 297-302 Dec. 1987
Avail: NTIS HC A14/MF A01

Momentum and reaction wheels with diameters of 45 and 60 cm producing angular momentum ceilings of 300 and 1000 Nms are presented. For the 1000 Nms wheel, an engineering model is being built and tested. Design and expected performance data are given. A modular family of flywheels with momentums between 1 and 1000 Nms is also presented. ESA

N88-21240# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
A FEEDBACK DOUBLE PATH COMPENSATING CONTROL STRUCTURE FOR THE ATTITUDE CONTROL OF A FLEXIBLE SPACECRAFT
DECIO CASTILHO CEBALLOS Feb. 1988 8 p Presented at the 5th IFAC/IFIP Symposium on Software for Computer Control,

South Africa, 26-28 Apr. 1988
(INPE-4464-PRE/1239) Avail: NTIS HC A02/MF A01

A Feedback Double Path Compensating (FDPC) control structure is considered for the attitude control of a flexible spacecraft, where vibration modes and modeling errors are present. Parameter optimization is applied for finding the controller so as to have optimized behavior for a high-order model. The fourth-order FDPC controller was tested for the one-axis attitude control of a spacecraft with flexible appendages, whose dynamics were approximated by a fourteenth-order linear invariant model. The FDPC controller was compared with a low-order controller and is shown to be less sensitive to modeling errors. Author

N88-22065# California Univ., Los Angeles. School of Engineering and Applied Science.
OPTIMAL CONTROL AND IDENTIFICATION OF SPACE STRUCTURES Final Report, 15 Aug. 1984 - 14 Dec. 1987
J. S. GIBSON 21 Dec. 1987 84 p
(Contract AF-AFOSR-0309-84)
(AD-A190033; AFOSR-88-0173TR) Avail: NTIS HC A05/MF A01
CSCL 22B

The focus of this research was to develop theoretical and computational tools for optimal control and adaptive parameter identification and control and adaptive parameter systems, primarily large flexible space structures. Approximation results for optimal control of infinite-dimensional systems were drived with numerical results. Also developed was an approximation theory for discrete-time optimal regulator problems, which included problems with flexible structures as a particular example. GRA

N88-22066# WEA, Cambridge, MA.
WAVE PROPAGATION AND DYNAMICS OF LATTICE STRUCTURES Final Report, 1 Sep. 1985 - 30 Sep. 1987
JAMES H. WILLIAMS, JR. 1 Oct. 1987 40 p
(Contract F49620-85-C-0148)
(AD-A190037; AFOSR-88-0062TR) Avail: NTIS HC A03/MF A01
CSCL 22B

One of the most attractive structural configurations for large space structures (LSS) for outer space applications is the repetitive lattice concept. Achieving the operational requirements of such structures will necessitate considerable knowledge of the dynamics, control, materials and nondestructive evaluation (NDE) of these structural systems. Wave propagation analyses provide potentially valuable perspectives from which to consider this broad range of analysis, design and synthesis issues. The theoretical and experimental results of a two-year research program on the wave propagation and dynamics of LSS are briefly reviewed. Potential benefits of wave propagation analyses in the vibration, parameter identification, dynamic failure, control and NDE of lattice structures have been identified and are summarized in this report. GRA

N88-22068# Department of the Air Force, Washington, DC. Directorate of Studies and Analysis.
FEEDBACK CONTROL OF DISTRIBUTED PARAMETER SYSTEMS WITH APPLICATIONS TO LARGE SPACE STRUCTURES Final Progress Report, 28 Dec. 1983 - 1 Sep. 1987
MARK J. BALAS 15 Oct. 1987 27 p
(Contract AF-AFOSR-0124-83)
(AD-A190536; AFOSR-87-2034TR) Avail: NTIS HC A03/MF A01
CSCL 22B

Large space structures exhibit distributed parameter behavior in their dynamics and thus must be described on infinite-dimensional state-spaces. However, the controller algorithm must be finite-dimensional to be implemented. The focus of this research has been to make finite-dimensional approximations of infinite-dimensional controllers which stabilize the distributed parameter system. The investigator has shown conditions under which Galerkin approximation schemes can yield finite-dimensional stabilizing controllers for linear distributed parameter systems. GRA

N88-22070# Clarkson Univ., Potsdam, NY.
NONLINEAR ANALYSIS AND OPTIMAL DESIGN OF DYNAMIC MECHANICAL SYSTEMS FOR SPACECRAFT APPLICATION Final Technical Report, 1 Feb. 1984 - 31 Jul. 1987
K. D. WILLMERT and M. SATHYAMOORTHY Sep. 1987 103 p
(Contract AF-AFOSR-0076-84)
(AD-A190644; AFOSR-87-2008TR) Avail: NTIS HC A06/MF A01
CSCL 22B

Analysis and optimal design procedures for planar as well as spatial mechanisms frequently used in space structures are developed. A nonlinear finite element procedure, developed originally for planar mechanisms during the initial stages of this research, has been modified considerably to handle complex mechanisms with sliding masses and mechanisms operating at relatively high speeds. The analysis takes into account the effects of geometric and material nonlinearities, vibrational effects and coupling of deformations. Numerical results have been reported for certain mechanism examples. The effects of nonlinearities on the dynamic behavior of mechanisms are significant. Considerable progress has been made in developing a nonlinear finite element procedure for 3-D mechanisms. Numerical results obtained for some example problems show the validity of the current 3-D formulation. A new optimization algorithm has also been developed based on the Gauss method to handle various types of nonlinear constraints with the goal of reducing the number of analyses required to obtain and optimal design. Details of the nonlinear finite element procedures as well as the optimization technique are available in published papers, copies of which are included. goal of reducing the number of analyses required to obtain an optimal design. Complete details of the nonlinear finite element procedures as well as the optimization technique are available in published papers, copies of which are included here in the Appendix. GRA

N88-22071# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
MOVING-BANK MULTIPLE MODEL ADAPTIVE ESTIMATION APPLIED TO FLEXIBLE SPACESTRUCTURE CONTROL M.S. Thesis
ROBERT W. LASHLEE, JR. Dec 1987 231 p
(AD-A190761; AFIT/GE/ENG/87D-36) Avail: NTIS HC A11/MF A01 CSCL 22D

This investigation focused on the use of moving-bank multiple model adaptive estimation and control (MMAE). Moving-bank MMAE reduces the computational burden of MMAE by implementing only a subset of the Kalman filters (9 filters versus 100 in this research) that are necessary to describe the system to be estimated/controlled. Important to the development of the moving-bank MMAE are the decision logics governing the selection of the subset of filters. The decision logics cover three situations: initial acquisition of unknown parameter values; tracking unknown parameter values; and reacquisition of the unknown parameters following a jump change in these parameter values. This thesis applied moving-bank MMAE to a rotating two bay truss model of a flexible spacestructure. The rotating two bay truss approximated a space structure that had a hub with appendages extending from the structure. The mass of the hub was large relative to the mass of the appendage. The mathematical model was developed using finite element analysis, transformed into modal formulation, and reduced using a method referred to as singular perturbations. Multiple models were developed by assuming that variation occurred in the mass and stiffness of the structure. GRA

N88-22378# Weidlinger Associates, New York, NY.
VIBRATIONS OF STRUCTURES WITH PARAMETRIC UNCERTAINTIES Final Report, Jan. 1984 - Sep. 1987
HAYM BENAROYA 31 Oct. 1987 75 p
(Contract F49620-84-C-0009)
(AD-A190400; AFOSR-87-1734TR) Avail: NTIS HC A04/MF A01
CSCL 22A

The focus of this research effort has been the study of structural dynamics with parameter and environmental uncertainties. The motivation for this study rests with the need to understand the dynamics and control of large space structures. Stochastic stability and output stationarity are also studied. GRA

N88-22924# Technische Hogeschool, Delft (Netherlands). Faculty of Aerospace Engineering.
MAXIMUM LIKELIHOOD PARAMETER IDENTIFICATION OF FLEXIBLE SPACECRAFT
QI PING CHU Mar. 1987 264 p
(LR-508; B8733287; ETN-88-92456) Avail: NTIS HC A12/MF A01

Identifying parameters of a flexible spacecraft model from in-orbit measurements is discussed, emphasizing mathematical modelling of a flexible spacecraft, using finite element analysis, and maximum likelihood parameter estimation, based on system models of reduced order with correlated process and measurement noise. It is shown that finite element analysis can be used to develop mathematical models of finite order of three-dimensional flexible spacecraft in arbitrary orbits. The following parameters in the flexible spacecraft model may be estimated from dynamic response measurements: Young's elasticity modulus, the Poisson ratio, the inertia matrix of the rigid main body and the jet input amplitudes. ESA

N88-22928# Virginia Univ., Charlottesville. Dept. of Electrical Engineering.
VIBRATION CONTROL OF LARGE STRUCTURES Final Technical Report, 1 Jan. - 31 Dec. 1986
ANTHONY K. AMOS Sep. 1987 33 p
(Contract F49620-86-K-0009)
(AD-A191358; UVA/525673/MAE88/101; AFOSR-88-0007TR) Avail: NTIS HC A03/MF A01 CSCL 22A

This is a study of vibration control for large space structures. Advantage is taken of the limiting performance characteristics of dynamic systems. This approach permits large problems with constraints to be analyzed. A modal formulation for the limiting performance was developed in order to enhance the applicability of limiting performance to large structural systems. One effort to develop an optimal control system is based on the limiting performance approach in combination with classical/optimal control theory. A limiting-performance/minimum-time solution was formulated to achieve the goal of rapid suppression of disturbances. Classical/optimal control studies show that a position loop might be useful in taking care of constraint controllers, such as proof-mass dampers. Finally, to derive feedback control law based on the limiting performance characteristics, parameter identification technique has been under investigation. GRA

N88-23819# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
TRAVELLING WAVE CONCEPTS FOR THE MODELING AND CONTROL OF SPACE STRUCTURES Final Report, 1 Mar. 1986 - 31 Oct. 1987
A. H. VONFLOTOW and S. R. HALL 31 Jan. 1988 442 p
(Contract F49620-86-C-0039)
(AD-A191235; AFOSR-88-0278TR) Avail: NTIS HC A19/MF A01 CSCL 22A

This report summarizes 20 months of research into Travelling Wave Concepts for the Modelling and Control of Space Structures. A good portion of the research has focused upon the development of techniques for the modelling of structural response in terms of disturbance propagation. Such models are of interest for several reasons: (1) Understanding the mechanisms that govern the propagation of disturbances through an elastic structure is useful for building intuition, for structural design and for design of active control, (2) Disturbance propagation models have the potential for providing high-fidelity analysis capabilities in response regimes where other techniques are inapplicable. Of considerable interest to the researchers at MIT is the response of elastic spacecraft to disturbances with significant spectral content at frequencies including many (even hundreds) of the spacecraft natural modes of structural vibration; and (3) Elastic disturbance propagation is a classic area of research in applied mechanics, having application in acoustics, seismology, microwave electronics, transducer design, biological fluid mechanics, design of mechanisms and machines, and many other areas. GRA

N88-23940*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Electrical Engineering.
THE LDCM ACTUATOR FOR VIBRATION SUPPRESSION
ERIC N. IDE and DOUGLAS K. LINDNER 1988 4 p
(Contract NAG1-719)
(NASA-CR-182898; NAS 1.26:182898) Avail: NTIS HC A02/MF A01 CSCL 09C

A linear dc motor (LDCM) has been proposed as an actuator for the COFS I mast and the COFS program ground test Mini-Mast. The basic principles of operation of the LDCM as an actuator for vibration suppression in large flexible structures are reviewed. Because of force and stroke limitations, control loops are required to stabilize the actuator, which results in a non-standard actuator-plant configuration. A simulation model that includes LDCM actuator control loops and a finite element model of the Mast is described, with simulation results showing the excitation capability of the actuator. Author

N88-23995 Purdue Univ., West Lafayette, IN.
CONTINUUM MODELING AND DYNAMIC ANALYSIS OF LARGE TRUSS STRUCTURES Ph.D. Thesis
BRAHIM NECIB 1987 163 p
Avail: Univ. Microfilms Order No. DA8729772

Truss Structures such as large space structures consist of a large number of truss members. Full scale finite element analysis which accounts for every member is computationally very expensive. In practice only the lower modes of vibration are of interest; the truss structure may be effectively represented by a continuous model. An extended Timoshenko beam model is derived to represent large truss structures where the extensional, flexural and shear deformations are coupled. Procedures for evaluating the equivalent continuum beam stiffnesses based on a substructure of the original system are presented. A higher order beam finite element based on the Timoshenko beam model is developed. Using this model, a number of truss structures is studied for free and forced vibration. Forces in the individual members obtained using the continuum model are compared with the full scale finite element solution applied to the original structure. Experiments are conducted on a scaled down truss model. Strain responses in members of the truss model due to impact force are measured. Comparison of the experimental results and the Timoshenko beam model is very accurate. Dissert. Abstr.

N88-24194*# Environmental Research Inst. of Michigan, Ann Arbor.
ORBITAL NAVIGATION, DOCKING AND OBSTACLE AVOIDANCE AS A FORM OF THREE DIMENSIONAL MODEL-BASED IMAGE UNDERSTANDING
J. BEYER, C. JACOBUS, and B. MITCHELL *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 37-46 Jun. 1988
Avail: NTIS HC A04/MF A01 CSCL 09B

Range imagery from a laser scanner can be used to provide sufficient information for docking and obstacle avoidance procedures to be performed automatically. Three dimensional model-based computer vision algorithms in development can perform these tasks even with targets which may not be cooperative (that is, objects without special targets or markers to provide unambiguous points). Role, pitch, and yaw of a vehicle can be taken into account as image scanning takes place, so that these can be correlated when the image is converted from egocentric to world coordinated. Other attributes of the sensor, such as the registered reflectance and texture channels, provide additional data sources for algorithm robustness. Author

N88-24195*# Alabama Univ., Huntsville. Center for Applied Optics.
GENETIC ALGORITHMS FOR ADAPTIVE REAL-TIME CONTROL IN SPACE SYSTEMS

J. VANDERZIJP and A. CHOUDRY *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 47-51 Jun. 1988
Avail: NTIS HC A04/MF A01 CSCL 09B

Genetic Algorithms that are used for learning as one way to control the combinational explosion associated with the generation of new rules are discussed. The Genetic Algorithm approach tends to work best when it can be applied to a domain independent knowledge representation. Applications to real time control in space systems are discussed. Author

N88-24665# Innovative Sciences, Inc., San Leandro, CA.
ELECTROMAGNETIC DAMPING AND VIBRATION ISOLATION OF SPACE STRUCTURES Final Report, 1 Feb. - 30 Sep. 1987
J. K. HULBERT and BRUCE W. MAXFIELD 5 Aug. 1987 66 p
(Contract F49620-87-C-0029)
(AD-A191492; AF080722A.DOC; AFOSR-88-0063TR) Avail: NTIS HC A04/MF A01 CSCL 10A

Structures used in the vacuum, zero gravity environment of space are quite different from earth-bound system. Vibrations induced in a space structure by the operation of equipment internal to the structure should, to the greatest extent possible, be dissipated through heat generation so that this vibrational energy is not simply redistributed throughout the structure. The usual restricted fluid flow dashpot damping system has several serious drawbacks when operating within a space environment. Phase 1 proposed the quantitative assessment of electromagnetic damping that results when conducting but non-magnetic body moves through a region of localized magnetic field. It was shown theoretically in the Phase 1 proposal that this damping should depend quadratically upon both the velocity and the magnetic field seen by the moving conducting body. From this, it follows that electromagnetic damping (ED) has the potential for both large energy and power dissipation. Although our initial approximate theoretical estimate predicted strong damping under ideal circumstances, the appropriate partial differential equations (PDE) had not been solved at the onset of Phase 1. Consequently, one could not calculate the damping magnitude that might be realized under practical conditions. GRA

N88-24666# Oklahoma Univ., Norman. Dept. of Mathematics.
ESTIMATION AND CONTROL OF DISTRIBUTED MODELS FOR CERTAIN ELASTIC SYSTEMS ARISING IN LARGE SPACE STRUCTURES Final Report, 1 Jul. 1984 - 30 Sep. 1987
LUTHER W. WHITE 30 Sep. 1987 62 p
(Contract AF AFOSR-0271-84)
(AD-A192120; AFOSR-88-0245TR) Avail: NTIS HC A04/MF A01 CSCL 22B

The goal of this research was to study estimation and control of elastic systems composed of beams and plates. Specifically, the research considered the problem of locating the optimal placement of controllers on a beam or plate and the problem of controlling general three-dimensional elastic models that incorporate nonlinear friction and contact laws on the boundary conditions. This final report summarizes those results. GRA

N88-24667 State Univ. of New York, Buffalo.
LOW AUTHORITY CONTROL OF LARGE SPACE STRUCTURES USING A CONSTRAINED THRESHOLD CONTROL FORMULATION Ph.D. Thesis
DAVID C. ZIMMERMAN 1987 208 p
Avail: Univ. Microfilms Order No. DA8727761

A new active control strategy for the vibration control of large space structures is presented. In this Low Authority-Threshold Control (LATC) method, the total energy requirement of the active controller is minimized by use of a threshold control formulation and by determining the control which minimizes an appropriate cost functional. The minimization results in a piecewise constant feedback control law and is suited for a distributed processing architecture because the designer is free to choose the allowable feedback structure. LATC is developed for single- and multi-degree of freedom structural models. The necessary conditions which define the optimal control law are determined using variational methods. Closed form and quasi-closed form solutions are developed to aid in the determination of the optimal control. The effect of observer-induced errors on LATC are investigated. The robustness of the control method in light of modelling errors is addressed. Finally, LATC has been compared with and contrasted to other similar control methods. Dissert. Abstr.

N88-24673# Tokyo Univ. (Japan). Inst. of Space and Astronautical Science.
DYNAMICS OF A FLEXIBLE ORBITING PLATFORM WITH MRMS
YASUHIRO MORITA and VINOD J. MODI (British Columbia Univ., Vancouver.) Feb. 1988 79 p
(ISSN-0285-6808; ISAS-RN-625) Avail: NTIS HC A05/MF A01

A relatively general formulation for studying dynamics of a flexible Mobile Remote Manipulator System (MRMS), supported by an orbiting flexible platform, is developed using the Lagrangian approach with generalized forces accounting for the environmental effects, damping, and control. The flexible members are treated as continuum and their flexural deformations represented by a series of admissible functions. The highly nonlinear, nonautonomous and coupled equations of motion, being not amenable to any known closed-form solution, are solved numerically. The computational algorithm is so structured as to isolate the effects of various system parameters thus helping in assessment of their relative importance. Effectiveness of the general formulation is illustrated by studying complex interactions between vibrational and librational degrees of freedom in the presence of MRMS maneuver over a range of system parameters and initial conditions. Results suggest that the MRMS maneuver can affect librational and vibrational response substantially and under critical combinations of parameters the system can become unstable. The information is fundamental to the design of a control strategy which, for a flexible system in the presence of generalized forces, has received virtually no attention. Author

N88-24674 North Carolina State Univ., Raleigh.
AUTOMATIC FEEDBACK CONTROL OF A RIGID BODY FOR FINITE DISPLACEMENTS Ph.D. Thesis
SUNIL SHRIKRISHNA KULKARNI 1987 93 p
Avail: Univ. Microfilms Order No. DA8800119

A control law for a suspended rigid body with a fixed support is described for large angular displacements. This control law is a function of angular velocities and quaternions, also known as Euler's parameters. Several missions forseen for the next generation of spacecraft require rapid large angle maneuvers followed by extremely accurate attitude acquisition upon completion of each maneuver. The control law is also useful for attitude control for space stations. This control law is also useful for suppressing swinging of translating rapid body with two degrees of freedom. The examples of objects which swing during transport range from a crane unloading cargo from a ship to manipulators handling artillery shells to a robot performing pick and place operations. In general, it is required to attenuate or suppress this swinging during all phases of the transport. Numerical simulations of this automatic feedback control system are made for a rigid body on Earth's surface and in orbit. It is shown that control algorithm is simple to implement and system stability is extremely robust with respect to external disturbances and inertial variations. Mass and inertial variation is eight to one. Dissert. Abstr.

N88-24989# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
EXPERIMENTAL STUDY OF ACTIVE VIBRATION CONTROL Final Technical Report, 30 Jan. 1986 - 31 Aug. 1987
WILLIAM L. HALLAUER, JR. 31 Aug. 1987 71 p
(Contract F49620-85-C-0024)
(AD-A191454; AFOSR-88-0060TR) Avail: NTIS HC A04/MF A01 CSCL 22B

Complementary experimental-theoretical studies were conducted on the following subjects related to the dynamics and control of flexible large spacecraft structures: 1) Transient wave propagation - Extensive results are presented for traveling waves in a laboratory structure excited by suddenly applied oscillatory point forces; 2) The dynamics of a thin-walled grid with a ridgid body slewing degree of freedom - The design, theoretical analysis, experimental testing, and experimental, and experimental-theoretical correlation are reported. Even after much refinement, the finite element model of the relatively simple structure did not satisfactorily predict the measured dynamic behavior; and 3) Active damping and control the slewing gird with the use of structure-borne accelerometers and reaction wheel actuators - The results of an active vibration damping experiment are presented. Also discussed are the serious practical problems encountered in this research and the potential for future experiments with simultaneous control of maneuvering and vibration. GRA

N88-25244*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
SINGLE-MODE PROJECTION FILTERS FOR MODAL PARAMETER IDENTIFICATION FOR FLEXIBLE STRUCTURES Final Report, for period ending 31 Dec. 1987
JEN-KUANG HUANG and CHUNG-WEN CHEN Feb. 1988 73 p
(Contract NAG1-655)
(NASA-CR-182680; NAS 1.26:182680) Avail: NTIS HC A04/MF A01 CSCL 12A

Single-mode projection filters are developed for eigensystem parameter identification from both analytical results and test data. Explicit formulations of these projection filters are derived using the orthogonal matrices of the controllability and observability matrices in the general sense. A global minimum optimization algorithm is applied to update the filter parameters by using the interval analysis method. The updated modal parameters represent the characteristics of the test data. For illustration of this new approach, a numerical simulation for the MAST beam structure is shown by using a one-dimensional global optimization algorithm to identify modal frequencies and damping. Another numerical simulation of a ten-mode structure is also presented by using a two-dimensional global optimization algorithm to illustrate the feasibility of the new method. The projection filters are practical for parallel processing implementation. Author

N88-25748*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TECHNOLOGIES FOR ANTENNA SHAPE AND VIBRATION CONTROL
EDWARD METTLER, ROBERT SCHEID, and DANIEL ELDRED *In its* Proceedings of the Mobile Satellite Conference p 477-482 May 1988
Avail: NTIS HC A23/MF A01 CSCL 17B

This paper describes the application of advanced control methods and techniques to the second- and third-generation mobile satellite (MSAT) configurations having wrap-rib offset feed construction. The technologies are generically applicable to other designs such as hoop-column and other elastically deformable non-rigid structures. The focus of the discussion is on reflector shape determination and control, dynamics identification, and pointing jitter suppression. Author

N88-26143 Rensselaer Polytechnic Inst., Troy, NY.
ADAPTIVE RESIDUAL MODE FILTER CONTROL OF DISTRIBUTED PARAMETER SYSTEMS FOR LARGE SPACE STRUCTURE APPLICATIONS Ph.D. Thesis
JANG JAMES OUYANG 1987 129 p
Avail: Univ. Microfilms Order No. DA8729317

Modal control is often proposed as a way to design stabilizing low order controllers for Distributed Parameter Systems (DPS). However, it is well known that such controllers, designed from a reduced order modal model, do not necessarily stabilize the actual DPS. It is proved that exponential closed-loop stability can always be achieved by the addition of a very low order Residual Mode Filter (RMF). Due to the uncertainty of modal data for the Large Space Structure (LSS), a real-time adaptive controller was designed and tested successfully via computer simulation. The controller, implemented in a digital minicomputer, consists of a modal Reduced-Order Model (ROM) controller, a bank of RMFs, and a bank of Frequency Locked Loops (FLLs) with associated bandpass filters for real-time parameter identification. Three DPS examples: a simply supported Euler-Bernoulli beam, a telegraph equation, and a Space Based Laser (SBL) beam expander are presented to illustrate the application of this concept. Dissert. Abstr.

N88-26390# Groningen Rijksuniversiteit (Netherlands). Subfaculteit Wiskunde en Informatica.
L(SUB INFINITY SYMBOL)-APPROXIMATIONS OF COMPLEX FUNCTIONS AND ROBUST CONTROLLERS FOR LARGE FLEXIBLE SPACE STRUCTURES
R. F. CURTAIN 1987 24 p
(PB88-186226; TW-281) Avail: NTIS HC A03/MF A01 CSCL 22B

A survey is presented of a theory for a frequency domain design of robust controllers for infinite dimensional systems using L sub infinity approximations. Applications to large flexible space structures are discussed. Author

N88-26693*# Old Dominion Univ., Norfolk, VA. Dept. of Civil Engineering.
EXPERIMENTAL AND THEORETICAL INVESTIGATION OF PASSIVE DAMPING CONCEPTS FOR MEMBER FORCED AND FREE VIBRATION Progress Report, period ending 31 Dec. 1987
ZIA RAZZAQ and DAVID W. MYKINS Dec. 1987 125 p
(Contract NAG1-336)
(NASA-CR-183082; NAS 1.26:183082) Avail: NTIS HC A06/MF A01 CSCL 20K

Potential passive damping concepts for use in space structures are identified. The effectiveness of copper brush, wool swab, and silly putty in chamber dampers is investigated through natural vibration tests on a tubular aluminum member. The member ends have zero translation and possess partial rotational restraints. The silly putty in chamber dampers provide the maximum passive damping efficiency. Forced vibration tests are then conducted with one, two, and three damper chambers containing silly putty. Owing to the limitation of the vibrator used, the performance of these dampers could not be evaluated experimentally until the forcing function was disengaged. Nevertheless, their performance is evaluated through a forced dynamic finite element analysis conducted as a part of this investigation. The theoretical results based on experimentally obtained damping ratios indicate that the passive dampers are considerably more effective under member natural vibration than during forced vibration. Also, the maximum damping under forced vibration occurs at or near resonance. Author

N88-27183# California Univ., Berkeley. Electronics Research Lab.
NUMERICAL OPTIMIZATION, SYSTEM THEORETIC AND SOFTWARE TOOLS FOR THE INTEGRATED DESIGN OF FLEXIBLE STRUCTURES AND THEIR CONTROL SYSTEMS Annual Technical Report, 30 Sep. 1986 - 29 Sep. 1987
E. POLAK 11 Apr. 1988 6 p
(Contract AF-AFOSR-86-0116)
(AD-A192927; AFOSR-88-0405TR) Avail: NTIS HC A02/MF A01 CSCL 01C

This research was motivated by a growing consensus that design specifications for projected controlled flexible aerospace structures, which are becoming larger and more flexible while performance requirements are becoming more stringent, can only be satisfied through an integrated design approach in which one determines simultaneously both structural and control system parameters. The work dealt with nonsmooth optimization techniques for the integrated design of flexible structures and their control systems. Nonsmooth optimization is an ideal tool for integrated design because it allows dynamic constraints and imposes no distinction between control system and structural variables. Major accomplishment include the development and testing of an optimal control algorithm which can be used to solve

both free and fixed time optimal control problems, such as the problem of moving a flexible structure, modeled by a partial differential equation, from an in initial to a final position in minimum time, while guaranteeing upper bounds on the controls and deformations of the structure over the entire maneuver; and laying the ground-work for the frequency domain design of finite dimensional feedback controllers for flexible structures, without resorting to modal truncation and suffering the resulting spillover effects.
GRA

N88-27587# European Nuclear Energy Agency, Paris (France).
VIBRATION CONTROL OF LARGE STRUCTURES Final Report, 1 Jan. 1986 - 31 Dec. 1987
WALTER D. PILKEV 1 Mar. 1988 46 p
(Contract F49620-86-K-0009)
(AD-A193317; UVA/525673/MAE88/103; AFOSR-88-0369TR)
Avail: NTIS HC A03/MF A01 CSCL 13M

This is a study of some fundamental aspects of the structural dynamics and vibration control of large structures. One focus is the development of a limiting performance formulation with minimum settling time which can accept multiple design objectives efficiently. This new formulation is intended to meet the need of rather comprehensive design objectives for the control of large space structures. Another objective of the study is to develop a systematic way of designing a control system based on the limiting performance characteristics. An indirect synthesis method is proposed. It is shown that closed loop control laws can be based on the optimal response trajectories in the time domain. The method is successfully applied to the control of proof-mass actuators.
GRA

N88-28083# Societe Nationale Industrielle Aerospatiale, Cannes (France).
LITERAL DYNAMIC MODELING [MODELISATION DYNAMIQUE LITTERALE]
C. GARNIER, P. RIDEAU, and Y. PAPEGAY (Nice Univ., France) 14 Jan. 1988 15 p In FRENCH
(REPT-881-440-114; ETN-88-92878) Avail: NTIS HC A03/MF A01

A computer program to create the literal dynamic model of systems composed of articulated flexible structures is presented. The procedure is characterized by the fact that the computing power is used to manipulate equations and algebra expressions till the end, without using numerical approximations. At this stage of development, the program deals with tree structures only. This type of structure is easier to study. The procedure is used to model large space structures of complex geometry.
ESA

N88-28950*# Smithsonian Astrophysical Observatory, Cambridge, MA.
ANALYTICAL INVESTIGATION OF THE DYNAMICS OF TETHERED CONSTELLATIONS IN EARTH ORBIT Quarterly Report No. 13, 1 Apr. - 30 Jun. 1988
ENRICO C. LORENZINI, GORDON E. GULLAHORN, and ROBERT D. ESTES Jul. 1988 124 p
(Contract NAS8-36606)
(NASA-CR-179371; NAS 1.26:179371) Avail: NTIS HC A06/MF A01 CSCL 22B

This Quarterly Report on Tethering in Earth Orbit deals with three topics: (1) Investigation of the propagation of longitudinal and transverse waves along the upper tether. Specifically, the upper tether is modeled as three massive platforms connected by two perfectly elastic continua (tether segments). The tether attachment point to the station is assumed to vibrate both longitudinally and transversely at a given frequency. Longitudinal and transverse waves propagate along the tethers affecting the acceleration levels at the elevator and at the upper platform. The displacement and acceleration frequency-response functions at the elevator and at the upper platform are computed for both longitudinal and transverse waves. An analysis to optimize the damping time of the longitudinal dampers is also carried out in order to select optimal parameters. The analytical evaluation of the performance of tuned vs. detuned longitudinal dampers is also part of this analysis. (2) The use of the Shuttle primary Reaction Control System (RCS) thrusters for blowing away a recoiling broken tether is discussed. A microcomputer system was set up to support this operation. (3) Most of the effort in the tether plasma physics study was devoted to software development. A particle simulation code has been integrated into the Macintosh II computer system and will be utilized for studying the physics of hollow cathodes.
Author

N88-28956# MATRA Espace, Toulouse (France).
STUDY OF STANDARD GENERIC APPROACH FOR SPACECRAFT (S/C) AUTONOMY AND AUTOMATION (PHASE 3). BOOK B: AUTONOMY CONCEPT APPLICATION EXAMPLE Final Report
Paris, France ESA Nov. 1987 324 p Prepared in cooperation with MBB GmbH, Ottobrunn, Fed. Republic of Germany and Dornier-Werke GmbH, Froedrichshafen, Fed. Republic of Germany
(Contract ESTEC-6358/85-NL-PP(SC))
(ESA-CR(P)-2555-VOL-2; ETN-88-92915) Avail: NTIS HC A14/MF A01

A generic system design concept for unmanned spacecraft is applied to EURECA. Allocation of autonomy requirements; system level applications; and subsystems are described. Functional and operational interfaces are discussed. Spacecraft modes of operation and the functional partitioning between the spacecraft and ground control are treated. On-board architecture; functional autonomy and on-board organization, interfaces, and the utilization of a local area network to interconnect the on-board management nodes are outlined.
ESA

N88-29794# Iowa Univ., Iowa City. Center for Computer Aided Design.
DYNAMICS OF ARTICULATED AEROSPACE STRUCTURES Final Report, 1 Dec. 1985 - 30 Nov. 1987
EDWARD J. HAUG 22 Apr. 1988 9 p
(Contract AF-AFOSR-0082-86)
(AD-A195685; AFOSR-88-0670TR) Avail: NTIS HC A02/MF A01 CSCL 20K

A unified variational approach to dynamics of flexible multibody systems has been developed and demonstrated on several test problems, including a deployable space structure, flexible manipulators with feedback control, spinning blades, impacting elastic bodies, and variety of mechanisms. A new recursive formulation was developed for dynamics of flexible multibody systems. This new formulation demonstrated in excess of an order of magnitude speed up in computation, compared to the Cartesian coordinate approach, with comparable accuracy and improved stability. A substructuring formulation that accounts for geometrically nonlinear deformation effects in spinning blades and large space structures was developed and demonstrated, using both the Cartesian coordinate and recursive relative coordinate formulations. The substructure technique was further extended to account for contact-impact effects between structural components. A new formulation of translational joints between flexible bodies was developed, to account for deformation due to sliding contacts.
GRA

N88-29842# Air Command and Staff Coll., Maxwell AFB, AL.
SENSOR AND ACTUATOR SELECTION FOR LARGE SPACE STRUCTURE CONTROL
MICHAEL L. DELORENZO Apr. 1988 41 p
(AD-A194912; ACSC-88-0725) Avail: NTIS HC A03/MF A01 CSCL 22B

This paper presents an algorithm which aids the controls engineer in specifying a sensor and actuator configuration for regulation of large scale, linear, stochastic systems such as a Large Space Structure (LSS). The algorithm uses a Linear Quadratic Gaussian (LQG) controller, an efficient weight selection technique based upon successive approximation, and a measure of sensor and actuator effectiveness to provide a final sensor and actuator configuration. This configuration enables the closed-loop system to meet output specifications with minimal input power. The algorithm involves no complex gradient calculations and has proven numerically tractable for large linear models. Additionally, the algorithm provides the controls engineer information on the important design issues of actuator sizing, reliability, redundancy, and optimal number. GRA

N88-29851# California Univ., Los Angeles.
THEORY OF FILTERING AND CONTROL WITH APPLICATION TO CONTROL OF LARGE SPACE STRUCTURES Final Report, 1 Sep. 1983 - 31 Aug. 1987
A. V. BALAKRISHNAN 30 Mar. 1988 8 p
(Contract AF-AFOSR-0318-83)
(AD-A195500; AFOSR-88-0666TR) Avail: NTIS HC A02/MF A01 CSCL 22B

This report summarizes accomplishments under a grant to study modeling, identification, and control of flexible structures and to study random fields with applications to laser beam distortion in a turbulent field. Research in flexible structures focused on deriving continuum models base upon partial differential equations and derived methods for the solution of the resulting boundary control problems. A robust controller for stabilization based upon the abstract Hilbert-space semigroup formulation was derived as was a stochastic control theory for partial differential equations. A white noise theory for random fields was derived which has applications to laser beam propagation in the atmosphere; in particular, it is used to model the turbulent field. GRA

N88-30124# State Univ. of New York, Albany. Research Foundation.
LASER SENSING FOR IDENTIFICATION AND CONTROL OF DISTRIBUTED PARAMETER SYSTEMS Final Report, 1 Dec. 1986 - 30 Nov. 1987
DANIEL J. INMAN 1 May 1988 17 p
(Contract AF-AFOSR-0099-87)
(AD-A195886; AFOSR-88-0654TR) Avail: NTIS HC A03/MF A01 CSCL 14B

This instrumentation award funded the purchase of a laser vibrometer system, mass computer data storage and data acquisition equipment. This equipment used in conjunction with existing vibration testing and control facilities provides a sophisticated low frequency velocity measurement system for use in identifying the coefficients in partial differential equation models of distributed mass structures. In addition, the vibrometer system provides straightforward and direct velocity feedback for such systems. These flexible structures characteristically have very low natural frequencies which cannot be detected by accelerometers. This system has and is being used to perform tests on models and sub-assemblies of large space structures for the purpose of evaluating existing identification and control strategies as well as to stimulate new research in the area of control, observers (estimators) and identification. Several intense experiments using the laser vibrometer were performed to measure the response of a quasi isotropic cantilevered beam with a removable tip mass excited by an impulse at various locations. This data was collected, stored, and sent to AFOSR researchers at Brown University transmitted using BITNET. The data was analyzed using a spline based estimation procedure, starting with a partial differential equation model of the structure. A clear advantage over modal methods based on a finite dimensional model of the same system was observed. GRA

N88-30134*# Catholic Univ. of America, Washington, DC. Dept. of Electrical Engineering.
ROBUST DESIGN OF DISTRIBUTED CONTROLLERS FOR LARGE FLEXIBLE SPACE STRUCTURES Final Technical Report
CHARLES C. NGUYEN Sep. 1988 33 p
(Contract NAG5-949)
(NASA-CR-183202; NAS 1.26:183202) Avail: NTIS HC A03/MF A01 CSCL 13I

Independent Modal Space Control (IMSC) method avoids control spillover generated by conventional control schemes such as Coupled Modal Control by decoupling the large flexible space structure into independent subsystems of second order and controlling each mode independently. The IMSC implementation requires that the number of actuators be equal to that of modeled modes, which is in general very huge. Consequently the number of required actuators is unrealizable. Two methods are proposed for the implementation of IMSC with reduced number of actuators. In the first method, the first m modes are optimized, leaving the last (n-m) modes unchanged. In the second method, generalized inverse matrices are employed to design the feedback controller so that the control scheme is suboptimal with respect to IMSC. The performance of the proposed methods is tested by performing computer simulation on a simply support beam. Simulation results are presented and discussed. Author

06

ELECTRONICS

Includes techniques for power and data distribution, antenna RF performance analysis, communications systems, and spacecraft charging effects.

A88-33448
KA, C, S FREQUENCY BANDS, MULTI-BEAM DEPLOYABLE ANTENNA SYSTEM FOR LARGE-CAPACITY COMMUNICATION SATELLITE
HIROYUKI KUMAZAWA, ISAO OHTOMO, YOSHIHIDE YAMADA, and TETSUO YASAKA (Nippon Telegraph and Telephone Public Corp., Radio Communications Systems Laboratories, Yokosuka, Japan) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 185-191. refs

The design and characteristics of electrical and structural models of a satellite-borne antenna system comprising large 3.5-m and 2.5-reflectors, feeders, and a tower for stowing the 3.7-m ID-class rocket are described. The reflectors, Ka band cluster horns, frequency-selective surfaces, C and S band horns, and the tower are integrally examined for electrical and mechanical performance. Measurement results with a verification model antenna are found to conform to design values. C.D.

A88-33629*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TELEMETRY HANDLING ON THE SPACE STATION DATA MANAGEMENT SYSTEM
VIRGINIA A. WHITELAW (NASA, Johnson Space Center, Houston, TX) IN: ITC/USA/'87; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 26-29, 1987. Research Triangle Park, NC, Instrument Society of America, 1987, p. 17-26.

This paper examines the impact of telemetry handling on the design of the onboard networks that are part of the Space Station Data Management System (DMS). An architectural approach to satisfying the DMS requirement for support of the high throughput needed for telemetry transport and for servicing distributed computer systems is discussed. Several of the functionality vs. performance tradeoffs that must be made in developing an optimized mechanism for handling telemetry data in the DMS are considered. C.D.

A88-33673
AUTOMATING SATELLITE CONTROL AND TELEMETRY NETWORKS
CONSTANCE J. GOLDEN (Ford Aerospace and Communications Corp., Sunnyvale, CA) IN: ITC/USA/'87; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 26-29, 1987. Research Triangle Park, NC, Instrument Society of America, 1987, p. 503-508.

Space Station and satellite control applications will require systems that have generic processing applicable to many different knowledge bases, the ability to learn from experience, the ability to handle situations not encountered before and behave at least as well as an expert would in the same new situation, the ability to respond in real time, and the ability to be formally verified and validated. A knowledge-based system approach that promises to meet all these requirements has been developed, and its applications to several satellite and network control applications are described. C.D.

A88-35099

THE USE OF ELECTRODYNAMIC TETHERS FOR GENERATING POWER AND THRUST IN SPACE

D. E. HASTINGS and MANUEL MARTINEZ-SANCHEZ (MIT, Cambridge, MA) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 701-716.
(AAS PAPER 86-366)

The concept of an electrodynamic tether is introduced. Such a tether works by inducing a current flow through the tether which closes in the ionosphere. It is shown that an electrodynamic tether used to generate power and thrust compares favorably with fuel cells and rockets. Some of the outstanding physical questions associated with operation of a tether are outlined and recent theoretical work reviewed. Author

A88-35112

DEPLOYABLE PRECISION REFLECTORS

BERND ABT (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 989-996.
(AAS PAPER 86-298)

Solid panel-based precision reflectors required to serve as antenna collectors by the larger satellites and orbiting radio telescopes, with diameters of up to 12 m, can be launched with existing or near-term-available launch systems without need for EVA for deployment. Attention is presently given to two state-of-the-art composite panel structure deployable antennas, wich illustrate proprietary German expertise in this field: the Multibeam Deployable Antenna for the 30/20 GHz communications payload of a future German satellite, and the Far Infrared and Submillimeter Space Telescope. O.C.

A88-35144

AI FOR SPACE MISSIONS

ROBERT W. HOBBS and RICHARD DESJARDINS (Computer Technology Associates, Inc., Lanham, MD) IN: Aerospace century XXI: Space sciences, applications, and commercial developments; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1453-1466. refs
(AAS PAPER 86-390)

The advantages and possible applications of AI for highly complex, multiple use, high data rate space environments of the 21st century are discussed. Advantages of AI include their ease of duplication and documentation, cost effectiveness, aggregation of the knowledge of several experts, and facilitation of robotics. A major difficulty in their use is the inability to validate systems employing AI techniques. Applications considered include systems design, spacecraft command and control, the control of on-board systems, and the operation of ground data systems. R.R.

A88-35274* Drexel Univ., Philadelphia, PA.

SYSTEM ARCHITECTURE OF MMIC-BASED LARGE APERTURE ARRAYS FOR SPACE APPLICATIONS

P. R. HERCZFELD, M. KAM (Drexel University, Philadelphia, PA), R. R. KUNATH, K. B. BHASIN (NASA, Lewis Research Center, Cleveland, OH), and NICK LA PRADE (RCA, RCA Astro-Electronics Div., Hightstown, NJ) IN: Optical technologies for space communication systems; Proceedings of the Meeting, Los Angeles, CA, Jan. 15, 16, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 164-172. Research supported by the Commonwealth of Pennsylvania. Previously announced in STAR as N87-20468. refs

The persistent trend to use millimeter-wave frequencies for satellite communications presents the challenge to design large-aperture phased arrays for space applications. These arrays, which comprise 100 to 10,000 elements, are now possible due to the advent of lightwave technology and the availability of monolithic microwave integrated circuits. In this paper, system aspects of optically controlled array design are studied. In particular, two architectures for a 40 GHz array are outlined, and the main system-related issues are examined: power budget, synchronization in frequency and phase, and stochastic effects. Author

A88-35275

KU-BAND (14GHZ) FIBER OPTIC COMMUNICATION LINKS FOR DISTRIBUTED ANTENNAS IN THE SPACE STATION

A. S. DARYOUSH, R. GLATZ, P. R. HERCZFELD (Drexel University, Philadelphia, PA), and M. P. BACCARINI (RCA, Government Communications Systems Div., Camden, NJ) IN: Optical technologies for space communication systems; Proceedings of the Meeting, Los Angeles, CA, Jan. 15, 16, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 173-182. Research supported by the Commonwealth of Pennsylvania and RCA. refs

Fiber optic networks are considered as a viable alternative to the conventional coaxial distribution systems for the Space Station. The multiple access communication subsystem provides 450-750 MHz data signal on offset quadrature phase shift keying (OQPSK) format to antenna-mounted electronics. For coherent communication 100 MHz frequency reference signal is transmitted to each module to phase lock a dielectric resonator oscillator at 14.15GHz. Experimental results of phase locked oscillator's spectral purity, synchronized via two commercial fiber-optic links at 1.3 and 0.8 microns are reported. These two fiber-optic links were compared in terms of phase noise degradation. Furthermore, experimental results of fiber-optic link linearity, third-order intermodulation distortion, dynamic range and effect of mixing between data and the frequency reference are reported. Author

A88-37285#

ANTENNAS FOR DIVERSE REQUIREMENTS

JOACHIM BOUKAMP Dornier-Post (English Edition) (ISSN 0012-5563), no. 1, 1988, p. 12-15.

An account is given of a major German aerospace manufacturer's state-of-the-art methods for development, design, construction, testing and certification of a wide variety of civilian and military communications and radar antennas. Attention is given to reflector antennas for very large aperture/wavelength ratios, slotted waveguide arrays in which the radiating aperture is synthesized by guided structures, and both microstrip arrays and active arrays, for the creation of very large area antennas. Antenna tests and measurements are conducted in an anechoic chamber. O.C.

A88-38098

BEYOND THE DIAMETER-WAVELENGTH-RATIO OF REFLECTOR ANTENNAS - A FILM LENS ANTENNA

YOSHIHIRO CHIKADA (Nobeyama Radio Observatory, Minamimaki, Japan) IN: Radio astronomy from space; Proceedings of the Workshop, Green Bank, WV, Sept. 30-Oct. 2, 1986. Charlottesville, VA, National Radio Astronomy Observatory, 1987, p. 221-224.

The theoretical basis and design concept of a thin-film-lens (TFL) space telescope for mm or sub-mm astronomical observations are discussed. The practical limitations on the size of reflector antennas (currently corresponding to a maximum diameter/wavelength ratio of about 10,000) are pointed out, and the results of Milne (1982) for an 89-cm dipole-array TFL antenna are extended to a much larger scale, stressing that TFLs operate using phase shift rather than delay, have no thickness, and should be relatively easy to fabricate and deploy. The allowable TFL parameters at different wavelengths are indicated in a graph: good observing qualities should be obtainable with a 30-m TFL for space VLBI in X-band, a 400-m TFL for the 2.6-mm band of CO, and a 1.5-km TFL for the 1.3-mm band of CO. T.K.

A88-38115
A TECHNIQUE FOR THE MEASUREMENT OF ENVIRONMENTAL LEVELS OF MICROWAVE RADIATION AROUND SATELLITE EARTH STATIONS
W. S. DAVIES and K. H. JOYNER (Telecom Australia Research Laboratories, Clayton) Journal of Electrical and Electronics Engineering, Australia (ISSN 0725-2986), vol. 7, Dec. 1987, p. 274-277. refs

Upper bounds for the levels of environmental microwave radiation measured in the vicinity of large aperture antennas using directive microwave probe antennas are discussed. In addition, the results of several surveys around satellite earth stations are summarized and presented. From the survey results it can be concluded that the environmental levels of microwave radiation outside the immediate vicinity of the antennas are many orders of magnitude below currently accepted exposure standards for members of the general public. As a point of comparison, it was found that the environmental levels of microwave radiation were generally comparable with the combined power densities of FM and TV transmissions measured in Melbourne suburbs. Author

A88-39423#
DEPLOYABLE 20/30-GHZ MULTI-BEAM ANTENNA FOR FUTURE COMMUNICATIONS SATELLITES
DIETMAR SCHEULEN Dornier-Post (English Edition) (ISSN 0012-5563), no. 2, 1988, p. 60-62.

The West German Multi-Beam Antenna, designated MEA, is a 20/30-MHz device of offset Cassegrain type with an offset paraboloid main reflector with a total of 16 beams. The primary challenge in the design of the reflector used is a surface contour accuracy of 0.2 mm rms, including production and deployment errors as well as thermal deformations in orbit. This high surface accuracy has been obtained by means of the 'replica' technique. The admissible deviations from the given contour were limited to less than 20 microns rms. Attention is given to the mold-forming method. O.C.

A88-42585
PRODUCTION OF GROUND STATE ATOMIC OXYGEN IN A MULTIFACTOR STRESS ENVIRONMENT
W. C. NEELY, T. C. YANG, J. P. WEY, E. J. CLOTHIAUX, and S. D. WORLEY (Auburn University, AL) IN: Space structures, power, and power conditioning; Proceedings of the Meeting, Los Angeles, CA, Jan. 11-13, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 313-316.

A system for the production of ground state atomic oxygen was designed with attention given to the use of a generation method in which the O-atom flux could be accurately characterized with respect to the exact identity and the absolute flux of the O-atom species produced. Moreover, the system was designed to permit multifactor stress studies of test samples upon exposure to the O-atom flux. Atomic oxygen generation is discussed as well as multifactor stress capability. K.K.

A88-43187* Drexel Univ., Philadelphia, PA.
OPTICAL TECHNOLOGY FOR SPACECRAFT ANTENNAS
P. R. HERCZFELD (Drexel University, Philadelphia, PA) IN: Fiber optic systems for mobile platforms; Proceedings of the Meeting, San Diego, CA, Aug. 20, 21, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 169-174. Research supported by General Electric Co., RCA, U. S. Navy, and NASA. refs

The issues involved in the design and implementation of high-speed fiberoptic distribution networks for spacecraft antennas are examined. The phased array antennas and antenna remoting are considered. The system requirements for these two generic system types are summarized, and their architectures are described. Optical beamforming of phased arrays is discussed, including beam control at the T/R module level, optical beam control on the fiber optic distribution network, and optical beamforming in free space. C.D.

A88-43715*# Maine Univ., Orono.
A NEW LINEARIZED THEORY OF LAMINAR FILM CONDENSATION OF TWO PHASE ANNULAR FLOW IN A CAPILLARY PUMPED LOOP
Y. K. HSU (Maine, University, Orono), T. SWANSON, and R. MCINTOSH (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 10 p. refs
(AIAA PAPER 88-2637)

Future large space based facilities, such as Space Station, will require energy management systems capable of transporting tens of kilowatts of heat over a hundred meters or more. This represents better than an order of magnitude improvement over current technology. Two-phase thermal systems are currently being developed to meet this challenge. Condensation heat transfer plays a very important role in this system. The present study attempts an analytic solution to the set of linearized partial differential equations. The axial velocity and temperature functions were found to be Bessel functions which have oscillatory behavior. This result agrees qualitatively with the experimental evidence from tests at both NASA Goddard Space Flight Center and elsewhere. Author

A88-44638* Kansas Univ. Center for Research, Inc., Lawrence.
DETERMINATION OF THE VERTICAL PATTERN OF THE SIR-B ANTENNA
RICHARD K. MOORE and MEHRZAD HEMMAT (University of Kansas Center for Research, Inc., Lawrence) International Journal of Remote Sensing (ISSN 0143-1161), vol. 9, May 1988, p. 839-847. refs
(Contract JPL-956902)

Determination of the antenna pattern is important for a spaceborne Synthetic Aperture Radar such as Shuttle Imaging Radar-B (SIR-B). For SIR-B the antenna was so large that apart from one section, no complete pattern could be measured on the ground. Attempts were made to measure the pattern while the shuttle was in space by using ground receivers and active radar calibrators. The method used and described is a supplement to these measurements. The vertical pattern of an antenna can be extracted from radar signals returned from regions whose scattering coefficients versus incidence angle characteristics are suitably flat and uniform. The method used shows that the main vertical lobe of the SIR-B antenna is slightly wider than previously reported (6.9 deg at 3 dB points versus 6.2 deg used in radiometric corrections). Author

A88-46799* Alabama Univ., Huntsville.
ELECTRON BEAM EXPERIMENTS AT HIGH ALTITUDES
R. C. OLSEN (Alabama, University, Huntsville) and H. A. COHEN (W. J. Schafer Associates, Inc., Arlington, VA) (COSPAR, URSI, and IAGA, Plenary Meeting, 26th, Symposium on Active Experiments, 1st, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, p. 161-164. Previously announced in STAR as N87-26946. refs
(Contract NAG3-620)

Experiments with the electron gun on the SCATHA satellite produced evidence of beam-plasma interactions, and heating of the low energy electrons around the satellite. These experiments were conducted near geosynchronous orbit, in the dusk bulge, and plasma sheet, with one short operation in the lobe regions, providing a range of ambient plasma densities. The electron gun was operated at 50 eV, with beam currents of 1, 10, and 100 micro-A. Data from electrostatic analyzers and the DC electric field experiment show that the satellite charged to near the beam energy in sunlight, if the beam current was sufficient. Higher ambient densities required higher beam currents. The electrostatic analyzers showed distribution functions which had peaks, or plateaus, at energies greater than the satellite potential. These measurements indicate heating of the ambient plasma at several Debye lengths from the satellite, with the heated plasma then accelerated into the satellite. It is likely that the ambient plasma is in fact the photoelectron sheath generated by the satellite. Author

A88-46804

RESULTS FROM A TETHERED ROCKET EXPERIMENT (CHARGE-2)

N. KAWASHIMA, S. SASAKI, K. I. OYAMA, K. HIRAO, T. OBAYASHI (Tokyo, University, Japan) et al. (COSPAR, URSI, and IAGA, Plenary Meeting, 26th, Symposium on Active Experiments, 1st, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, p. 197-201. refs

A tethered payload experiment (Charge-2) was carried out as an international program between Japan and the USA using a NASA sounding rocket at White Sands Missile Range. The objective of the experiment was to perform a new type of active experiment in space by injecting an electron beam from a mother-daughter rocket system connected with a long tether wire. The electron beam with voltage and current up to 1 kV and 80 mA (nominal) was injected from the mother payload. An insulated conductive wire of 426 m length connected the two payloads, the longest tether system flown so far. The electron gun system and diagnostic instruments (plasma, optical, particle and wave) functioned correctly throughout the flight. The potential rise of the mother payload during the electron beam emission was measured with respect to the daughter payload. The beam trajectory was detected by a camera onboard the mother rocket. Wave generation and current induction in the wire during the beam emission were also studied. Author

A88-46805

THEORY OF THE ELECTRODYNAMIC TETHER

C. E. RASMUSSEN (Utah State University, Logan) and P. M. BANKS (Stanford University, CA) (COSPAR, URSI, and IAGA, Plenary Meeting, 26th, Symposium on Active Experiments, 1st, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, p. 203-211. refs

The motion of the long conducting wire of a tethered satellite across the geomagnetic field creates an emf of about 0.1-0.2 V/m along the length of the tether. This emf can be utilized to excite wave modes in the ionosphere ranging in frequency from the magnetohydrodynamic regime to the upper hybrid frequency. The emitted spectrum depends principally upon the size (in the direction perpendicular to the magnetic field) of the moving source. The amplitude of radiated waves having a frequency less than the ion cyclotron frequency has been calculated. The shear Alfven wave is always excited and forms an 'Alfven-wing' structure whose amplitude diminishes as the length of the tether increases. In the near-field zone, the emitted waves propagate along magnetic field lines as packets but disperse into individual Fourier components as the far field is reached. However, as the distance to the far-field zone is at least 10 to the 6th kilometers for typical tether configurations, the shear Alfven wave will be reflected by the earth's ionosphere with accompanying coupling to the compressional Alfven mode before the far field is reached. Author

A88-46806

LABORATORY MODEL OF A TETHERED SATELLITE - CURRENT COLLECTION UPON AND SHEATH FORMATION AROUND A CHARGED BODY IN A DRIFTING MAGNETOPLASMA

J.-P. LEBRETON (ESA, Space Science Dept., Noordwijk, Netherlands), C. BONIFAZI, M. SMARGIASSI (CNR, Istituto di Fisica dello Spazio Interplanetario, Frascati, Italy), and R. DEBRIE (CNRS, Laboratoire de Physique et de Chimie de l'Environnement, Orleans, France) (COSPAR, URSI, and IAGA, Plenary Meeting, 26th, Symposium on Active Experiments, 1st, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, p. 213-217, 219, 220. refs

The I-V characteristic and the sheath of a Tethered Satellite laboratory model are investigated in a simulated ionospheric plasma environment with particular emphasis on magnetic field effects. The current collection in the ion regime can be described by a power law: I varies as V exp 0.85 and no magnetic field effect is observed. Strong magnetic field effects are observed in the electron current collection regime which cannot be described by a single power law. In the presence of a magnetic field transverse to the plasma flow, the wake of a highly positively charged body is found sideways the body rather than downstream. Author

A88-46807* Colorado State Univ., Fort Collins.

PLASMA CONTACTOR DESIGN FOR ELECTRODYNAMIC TETHER APPLICATIONS

PAUL J. WILBUR and THOMAS G. LAUPA (Colorado State University, Fort Collins) (COSPAR, URSI, and IAGA, Plenary Meeting, 26th, Symposium on Active Experiments, 1st, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, p. 221-224. refs
(Contract NGR-06-002-112; NAG9-120)

The plasma contacting process is described and experiments are discussed that suggest the key role that cold ions play in establishing a low impedance plasma bridge that can conduct current in either direction between a contactor electrode and a dilute plasma. A ring cusp contactor is shown to provide from 1000-mA of electron emission to 500-mA of electron collection as its bias relative to a simulated space plasma is varied through an 80-v range. Author

A88-47970#

ELECTROSTATIC CHARGING AND ARC DISCHARGES ON SATELLITE DIELECTRICS SIMULATED BY ELECTRON BEAM

HARUHISA FUJII, YOSHIKAZU SHIBUYA (Mitsubishi Electric Corp., Amagasaki, Japan), TOSHIO ABE, RITAROH KASAI (Mitsubishi Electric Corp., Kamakura, Japan), and HIRONOBU NISHIMOTO (National Space Development Agency of Japan, Tsukuba) (Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers, p. 156-163) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 156-161. Previously cited in issue 19, p. 2741, Accession no. A86-40597. refs

A88-50306

FIBER BASED PHASED ARRAY ANTENNAS

JOEL L. GUGGENMOS and RONALD L. JOHNSON (TRW, Inc., Defense Communications Div., Redondo Beach, CA) IN: Optical technology for microwave applications III; Proceedings of the Meeting, Orlando, FL, May 19, 20, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 70-77. refs

A phased array antenna is a multielement antenna capable of agile electronic beam forming and steering requiring several hundred high frequency, wide bandwidth, interconnections. Conventional distribution methods using waveguide or coax are impractical because they exhibit high attenuation, limited bandwidth, sensitivity to EMI, temperature drifts, and phase instability. Additionally, for large numbers of antenna elements, the size and weight of such systems make them impossible for large scale implementation on communication satellites. RF signal distribution via fiber optic technology is a potential solution to these phased array antenna problems. Author

A88-50308

COMPARISON OF FIBER OPTIC AND SPACE FEED FOR LARGE APERTURE PHASED ARRAY ANTENNAS

NILS V. JESPERSEN and PETER R. HERCZFELD (Drexel University, Philadelphia, PA) IN: Optical technology for microwave applications III; Proceedings of the Meeting, Orlando, FL, May 19, 20, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 88-91.

Two technologies which are potential candidates for distributing control and intelligence information in large phased array antennas, are space feeding and fiber optic corporate feeding. A comparison of the two technologies is presented in both qualitative and quantitative form. The comparison is embodied in the hypothetical cases of a V-band and an L-band spaceborne imaging radar. Size, weight, power and performance impacts of the two feeding methods are contrasted. Author

A88-51341#

SPACECRAFT SURFACE COATING HEAT GENERATION BY CHARGED PARTICULATE OF THE NATURAL SPACE ENVIRONMENT

RICHARD D. JIMENEZ (New Mexico, University; Aerospace Corp., Albuquerque) and MOHAMED S. EL-GENK (New Mexico, University, Albuquerque) ASME, Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987. 9 p. Research supported by the Aerospace Corp. refs

(ASME PAPER 87-WA/HT-13)

Characteristics of charged particulate trapped within the earth's geomagnetic fields are discussed and their interactions with absorbing media are highlighted. Fundamental treatments for determining primary particle energy transfer of energetic protons and electrons to absorbing media are presented and applied to various simulations of particle flux levels. In particular, the heating of a .025 cm thick zinc orthotitanate coating and tantalum substrate by charged particulate is treated and resulting predicted temperatures are presented. Degradation data of spacecraft surface coating materials are presented and some discussion of established and potential degradation mechanisms are featured. Author

A88-51391#

REAL-TIME, AUTOMATIC VEHICLE-POTENTIAL DETERMINATION FROM ESA MEASUREMENTS - THE DISTRIBUTION FUNCTION ALGORITHM

STANLEY L. SPIEGEL (Lowell, University, MA) and HERBERT A. COHEN (USAF, Geophysics Laboratory, Hanscom AFB, MA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, May-June 1988, p. 234-238. refs

(Contract F49620-79-C-0038; AF-AFOSR-85-0015)

A spacecraft-borne electrostatic analyzer's positive ion count measurements at GEO are presently used by a novel technique to ascertain the plasma distribution function, on the basis of which the spacecraft's potential can be inferred with high accuracy and in real time. The method has been found to be highly successful in the test interval containing natural charging events, irrespective of plasma stability. The computational and storage requirements of the technique are suitable for real-time space vehicle potential determination. O.C.

A88-51392#

SEVERAL SPACECRAFT-CHARGING EVENT ON SCATHA IN SEPTEMBER 1982

H. C. KOONS, P. F. MIZERA, J. L. ROEDER, and J. F. FENNELL (Aerospace Corp., El Segundo, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, May-June 1988, p. 239-243. Previously cited in issue 08, p. 1059, Accession no. A87-22659. refs

(Contract F04701-85-C-0086)

A88-52333* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

SPACE STATION PHOTOVOLTAIC POWER MODULES

CHARLES A. TATRO (NASA, Lewis Research Center, Cleveland, OH) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-21 to 5-33. refs

Silicon cell Photovoltaic (PV) power modules are key components of the Space Station Electrical Power System (EPS) scheduled to begin deployment in 1994. Four PV power modules, providing 75 KWe of user ac power, form the cornerstone of the EPS; which is comprised of Photovoltaic (PV) power modules, Solar Dynamic (SD) power modules, and the Power Management and Distribution (PMAD) system. The PV modules are located on rotating outboard sections of the Space Station (SS) structure and each module incorporates its own nickel-hydrogen energy storage batteries, its own thermal control system, and some autonomous control features. The PV modules are a cost-effective and technologically mature approach for providing reliable SS electrical power and are a solid base for EPS growth, which is expected to reach 300 KWe by the end of the Space Station's 30-year design lifetime. Author

A88-52339

GROUND BASED OPERATIONS SUPPORT BY ARTIFICIAL INTELLIGENCE

RAINER GRUEN and ALBRECHT KELLNER (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 6-1 to 6-10.

The application of AI as support for ground-based space operations is considered, and the question of the management of large distributed AI-systems within a complex communications environment is addressed. The future European ground infrastructure is discussed, with special attention given to the space station Columbus, the Ariane 5 launcher, the Hermes spaceplane, and the European data relay satellite. Applicability of AI to the areas of cognition, analysis and interpretation, and the synthesis of activity sequences and scheduling is reviewed. Also considered are AI technologies, knowledge management, and system integration. R.R.

A88-53470* California Univ., La Jolla.

A STUDY OF SCATHA ECLIPSE CHARGING

WEI-WEI LI and ELDEN C. WHIPPLE (California, University, La Jolla) Journal of Geophysical Research (ISSN 0148-0227), vol. 93, Sept. 1, 1988, p. 10041-10046. refs

(Contract NGL-05-005-007)

The events of charging of the SCATHA satellite in eclipse were investigated and correlated to the spacecraft surface-averaged and angle-averaged fluxes. It is shown that the large negative vehicle potentials produced in eclipse correlated with the net current due to the high-energy plasma electrons. These potentials also depend on the ion energy, ion current, and the average ion yield. An explanation for this behavior is proposed. I.S.

A88-53779

ADVANCED SPACE POWER SYSTEMS

V. L. TEOFILO (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) SAWE, Annual Conference, 46th, Seattle, WA, May 18-20, 1987. 11 p.

(SAWE PAPER 1762)

A review of electrical power source concepts for application to near term space missions is presented along with a comparison of their weight and area estimates. The power sources reviewed include photovoltaic solar arrays, solar concentrators, radioisotopic thermoelectric generators (RTG), Dynamic Isotope Power Subsystems (DIPS) and nuclear reactors. The solar arrays are found to be the lightest systems in the 1-6 kWe range for a 10 year mission life but they have the largest area of the practicable sources. Solar dynamics has the smallest area of the solar systems and has the lightest mass above 20 kWe of all the solar sources when a closed Brayton cycle power conversion system is used. The DIPS is the lightest weight system from 6 to 11 kWe above which the thermionic reactor is the lightest assuming a 38 foot boom is used to minimize shield weight. Author

A88-54749

FOCAL-PLANE AND APERTURE-PLANE HETERODYNE ARRAY RECEIVERS FOR MILLIMETER-WAVE RADIOASTRONOMY - A COMPARISON

J. ANTHONY MURPHY (Maynooth College, Ireland) and RACHAEL PADMAN (Mullard Radio Astronomy Observatory, Cambridge, England) International Journal of Infrared and Millimeter Waves (ISSN 0195-9271), vol. 9, Aug. 1988, p. 667-704. refs

Maximization of the throughput of a single large antenna is investigated for the cases of focal plane imaging arrays and aperture plane phased arrays. Trade-offs between these two types of arrays are considered with respect to field of view, sampling efficiency, and time to map a source. Limits imposed on the number of feed elements in an imaging array by the deterioration in aperture efficiency off-axis are determined. Advantages of the focal plane array over the aperture plane array include simpler electronics and fewer restrictions on the field of view. R.R.

A88-54853*# National Aeronautics and Space Administration, Washington, DC.

CONNECTIVITY IS THE KEY

DANA L. HALL (NASA, Space Station Program Office, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 26, Sept. 1988, p. 24-27.

Connectivity that would allow users at home to interact with an experiment in space and with facilities and services worldwide is a primary goal of the international Space Station program. The systems supporting such connectivity, including the Space Station Information System, the Technical and Management Information System, and the Software Support Environment, are discussed here. The primary purposes of each system and their operational data are addressed. C.D.

N88-20569# National Aerospace Lab., Amsterdam (Netherlands). Space Div.

FEASIBILITY DEMONSTRATION OF A SENSOR FOR HIGH-QUALITY TWO-PHASE FLOW

A. A. M. DELIL 9 Jan. 1987 32 p
(Contract NIVR-2502-N)
(NLR-TR-87009-U; B8729599; ETN-88-91724) Avail: NTIS HC A03/MF A01

Systems to control the liquid flow rates into evaporative cold plates in the two-phase flow heat transport systems for the Columbus Space Platform and the Space Station are discussed. Candidate components for such a control system are sensors monitoring the (very high) mixture quality at the cold plate exit lines, control algorithms, and actuators (valves) to adjust the liquid flow rates. The feasibility of a dedicated sensor is theoretically and experimentally demonstrated. Recommendations for the further development of the sensor are presented. ESA

N88-21243*# Hughes Research Labs., Malibu, CA.

SPACECRAFT DIELECTRIC SURFACE CHARGING PROPERTY DETERMINATION Final Report, Sep. 1980 - Nov. 1981

W. S. WILLIAMSON Oct. 1987 84 p
(Contract NAS3-22540)
(NASA-CR-180879; NAS 1.26:180879) Avail: NTIS HC A05/MF A01 CSCL 22B

The charging properties of 127 micron thick polyimide, (a commonly used spacecraft dielectric material) was measured under conditions of irradiation by a low-current-density electron beam with energy between 2 and 14 keV. The observed charging characteristics were consistent with predictions of the NASCAP computer model. The use of low electron current density results in a nonlinearity in the sample-potential versus beam-energy characteristic which is attributed to conduction leakage through the sample. Microdischarges were present at relatively low beam energies. Author

N88-21251*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

POWER TRANSMISSION STUDIES FOR TETHERED SP-100

DAVID J. BENTS 1988 16 p Proposed for presentation at the 23rd Intersociety Energy Conversion Engineering Conference, Denver, Colo., 31 Jul. - 5 Aug. 1988; sponsored by ASME, AIAA, ANS, SAE, IEEE, ASC and AIChE
(NASA-TM-100864; E-4081; NAS 1.15:100864) Avail: NTIS HC A03/MF A01 CSCL 10B

The tether and/or transmission line connecting the SP-100 to space station presents some unorthodox challenges in high voltage engineering, power transmission, and distribution. The line, which doubles as a structural element of this unusual spacecraft, will convey HVDC from SP-100 to the platform in low Earth orbit, and environment where the local plasma is sufficient to cause breakdown of exposed conductors at potentials of only a few hundred volts. Its anticipated several years operation, and continuously accumulating exposure to meteoroids and debris, raises an increasing likelihood that mechanical damage, including perforation, will be sustained in service. The present concept employs an array of gas insulated solid wall aluminum coaxial tubes; a conceptual design which showed basic feasibility of the SP-100 powered space station. Practical considerations of launch, deployment and assembly have lead to investigation of reel deployable, dielectric insulated coaxial cables. To be competitive, the dielectric would have to operate reliably in a radiation environment under electrical stresses exceeding 50 kV/cm. The SP-100 transmission line high voltage interfaces are also considered. Author

N88-21254*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

POWER SYSTEMS FOR PRODUCTION, CONSTRUCTION, LIFE SUPPORT AND OPERATIONS IN SPACE

RONALD J. SOVIE 1988 16 p Proposed for presentation at Space '88, Albuquerque, N. Mex., 29-31 Aug. 1988; sponsored by the American Society of Civil Engineers
(NASA-TM-100838; E-4026; NAS 1.15:100838) Avail: NTIS HC A03/MF A01 CSCL 22B

As one looks to man's future in space it becomes obvious that unprecedented amounts of power are required for the exploration, colonization, and exploitation of space. Activities envisioned include interplanetary travel and LEO to GEO transport using electric propulsion, Earth and lunar observatories, advance space stations, free-flying manufacturing platforms, communications platforms, and eventually evolutionary lunar and Mars bases. These latter bases would start as camps with modest power requirements (kWes) and evolve to large bases as manufacturing, food production, and life support materials are developed from lunar raw materials. These latter activities require very robust power supplies (MWes). The advanced power system technologies being pursued by NASA to fulfill these future needs are described. Technologies discussed will include nuclear, photovoltaic, and solar dynamic space power systems, including energy storage, power conditioning, power transmission, and thermal management. The state-of-the-art and gains to be made by technology advancements will be discussed. Mission requirements for a variety of applications (LEO, GEO, lunar, and Martian) will be treated, and data for power systems ranging from a few kilowatts to megawatt power systems will be represented. In addition the space power technologies being initiated under NASA's new Civilian Space Technology Initiative (CSTI) and Space Leadership Planning Group Activities will be discussed. Author

N88-21374*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

POWER COMPONENTS FOR THE SPACE STATION 20-KHZ POWER DISTRIBUTION SYSTEM

DAVID D. RENZ 1988 10 p Proposed for presentation at the 23rd Intersociety Energy Conversion Engineering Conference, Denver, Colo., 31 Jul. - 5 Aug. 1988; sponsored by ASME, AIAA, ANS, SAE, IEEE, ACS and AIChE
(NASA-TM-100866; E-4092; NAS 1.15:100866) Avail: NTIS HC A02/MF A01 CSCL 09C

Since 1984, NASA Lewis Research Center was developing high power, high frequency space power components as part of The Space Station Advanced Development program. The purpose of The Advanced Development program was to accelerate existing component programs to ensure their availability for use on the Space Station. These components include a rotary power transfer device, remote power controllers, remote bus isolators, high power semiconductor, a high power semiconductor package, high frequency-high power cable, high frequency-high power connectors, and high frequency-high power transformers. All the components were developed to the prototype level and will be installed in the Lewis Research Center Space Station power system test bed. Author

N88-21375*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MULTI-HUNDRED KILOWATT ROLL RING ASSEMBLY EVALUATION RESULTS
DAVID D. RENZ 1988 10 p Proposed for presentation at the 23rd Intersociety Energy Conversion Engineering Conference, Denver, Colo., 31 Jul. - 5 Aug. 1988; sponsored by ASME, AIAA, ANS, SAE, IEEE, ACS and AIChE
(NASA-TM-100865; E-4091; NAS 1.15:100865) Avail: NTIS HC A02/MF A01 CSCL 13B

NASA Lewis Research Center has been evaluating low loss multi-hundred-kilowatt Roll Ring assemblies (an 8 circuit and a 4 circuit) for use on Space Station as the rotating joint power transfer device. In this device ac or dc power is transferred across the rotating joint through compressed rotating flexures. Results and conclusions of the evaluation program are presented. Author

N88-22939*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE APPLICATION OF HIGH TEMPERATURE SUPERCONDUCTORS TO SPACE ELECTRICAL POWER DISTRIBUTION COMPONENTS
PAUL R. ARON and IRA T. MYERS 1988 8 p Proposed for presentation at the 23rd Intersociety Energy Conversion Engineering Conference, 31 Jul. - 5 Aug. 1988; sponsored by ASME, AIAA, ANS, SAE, IEEE, ACS and AIChE
(NASA-TM-100901; E-4153; NAS 1.15:100901) Avail: NTIS HC A02/MF A01 CSCL 10B

Some important space based electrical power distribution systems and components are examined to determine what might be achieved with the introduction of high temperature superconductors (HTS). Components that are compared in a before and after fashion include transformers, transmission lines, and capacitors. It is concluded that HTS has its greatest effect on the weight associated with transmission lines, where the weight penalty could be reduced by as much as 130 kg/kW/km of cable. Transformers, because 28 percent of their mass is in the conductor, are reduced in weight by the same factor. Capacitors are helped the least with only negligible savings possible. Finally, because HTS can relax the requirement to use alternating current in order to reduce conductor mass, it will be possible to generate significant savings by eliminating most transformers and capacitors. J.P.B.

N88-23073*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CASE STUDY OF ACTIVE ARRAY FEED COMPENSATION WITH SIDELOBE CONTROL FOR REFLECTOR SURFACE DISTORTION
R. J. ACOSTA, A. J. M. ZAMAN, E. A. BOBINSKY, A. R. CHERRETTE, and S. W. LEE (Illinois Univ., Urbana-Champaign.) 1988 7 p Presented at the 1988 AP-S/URSI International Symposium, Syracuse, N.Y., 6-10 Jun. 1988; sponsored by IEEE
(NASA-TM-100287; E-3932; NAS 1.15:100287) Avail: NTIS HC A02/MF A01 CSCL 20N

The feasibility of electromagnetically compensating for reflector surface distortions has been investigated. The performance characteristics (gain, sidelobe levels, etc.) of large communication antenna systems degrade as the reflector surface distorts mainly due to thermal effects from a varying solar flux. The techniques described in this report can be used to maintain the design performance characteristics independently of thermal effects on the reflector surface. With the advent of monolithic microwave integrated circuits (MMIC), a greater flexibility in array-fed reflector system design can be achieved. MMIC arrays provide independent control of amplitude and phase for each of many radiating elements of the feed array. It is assumed that the surface characteristics (x,y,z, its first and second derivatives) under distorted conditions are known. Author

N88-23649*# Colorado State Univ., Fort Collins. Dept. of Mechanical Engineering.
SPACE PLASMA CONTACTOR RESEARCH, 1987 Annual Report, 1 Jan. 1987 - 1 Jan. 1988
PAUL J. WILBUR Jan. 1988 87 p
(Contract NAG3-776)
(NASA-CR-182148; NAS 1.26:182148) Avail: NTIS HC A05/MF A01 CSCL 20I

A simple model describing the process of electron collection from a low pressure ambient plasma in the absence of magnetic field and contactor velocity effects is presented. Experimental measurments of the plasma surrounding the contactor are used to demonstrate that a double-sheath generally develops and separates the ambient plasma from a higher density, anode plasma located adjacent to the contactor. Agreement between the predictions of the model and experimental measurements obtained at the electron collection current levels ranging to 1 A suggests the surface area at the ambient plasma boundary of the double-sheath is equal to the electron current being collected divided by the ambient plasma random electron current density; the surface area of the higher density anode plasma boundary of the double-sheath is equal to the ion current being emitted across this boundary divided by the ion current density required to sustain a stable sheath; and the voltage drop across the sheath is determined by the requirement that the ion and electron currents counterflowing across the boundaries be at space-charge limited levels. The efficiency of contactor operation is shown to improve when significant ionization and excitation is induced by electrons that stream from the ambient plasma through the double-sheath and collide with neutral atoms being supplied through the hollow cathode. Author

N88-24321# General Electric Co., Philadelphia, PA. Space Systems Div.
TURBOMACHINERY IN SPACE
T. S. CHAN, W. S. CHIU, R. E. TROEGER, and M. SHAH *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 285-288 1987
(Contract F33615-85-C-2544)
Avail: NTIS HC A22/MF A01

The need to supply high levels of electrical power in the multimegawatt (MMW) range for short durations, such as the Strategic Defense Initiative (SDI) missions, is anticipated in future space applications. A potential power subsystem candidate based upon near-term technology is the turbogenerator consisting of a power turbine driving a generator or alternator. Numerous studies have shown that turbogenerators using either nuclear or chemical heat source can provide the burst MMW power at lowest system mass. However, no full consideration has yet been given to other essential issues associated with operating the power subsystem, such as dynamic interactions with the spacecraft, thermal management, fuel storage and control, and effluent management. The status of a 3 year study to assess the feasibility of turbomachinery for space application is presented. The hardware studied includes: the turbine and its components; the electrical generator and power conditioning elements; and the space platform design. The effects, interactions, and performance of all subsystems are analyzed. Author

N88-24392# Los Alamos National Lab., NM.
INDIVIDUAL SATELLITE POWER REQUIREMENTS CALCULATED FROM SPECIFIED CONSTELLATION PERFORMANCE
DUANE R. MARR, RUSSELL B. KIDMAN, and W. GREG LACEY *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 85-88 1988 Sponsored by DOE, Washington, D.C. and DOD, Washington, D.C.
Avail: NTIS HC A99/MF A01

The development of individual station power requirements in a space-based SDI system needs to be made in the context of the defensive effectiveness of the system as a whole, and not on the maximum effectiveness of the individual platform. It is possible, for instance, that a few platforms with high effectiveness might be a less cost effective way to achieve a given level of performance than a larger number of platforms, each with a lesser effectiveness. In order to make a tradeoff study, one needs to calculate the performance of the defensive system as a whole. Further, total system power is important because it is a major determinant of the launch resources required. An evaluation of the resource requirements for such a system thus requires a knowledge not only of the individual station power but also of the number of platforms. These are just two of the problems that the computer program DEFENSE can help solve. DEFENSE is a computer simulation of the engagement of a space-based SDI defense against an offensive threat containing hundreds of thousands of objects. Given the characteristics of a defensive platform and the number of such platforms, DEFENSE calculates the performance of the system as a whole. It can thus be used to determine the size of (numbers in) the constellation required for a given level of performance. It can also help optimize the system through the use of tradeoff studies. Author

N88-24670# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SIMULATIONS OF THE ELECTROSTATIC CHARGING OF ESA COMMUNICATIONS SATELLITES
E. J. DALY and W. R. BURKE Dec. 1987 45 p
(ESA-STM-239; ISSN-0379-4067; ETN-88-92555) Avail: NTIS HC A03/MF A01

The NASA Charging Analyzer Program (NASCAP) was used to investigate the electrostatic charging of three-axis stabilized satellites in geostationary plasma environments. Capabilities and limitations are discussed and the use of NASCAP in anomaly investigations is described. Three-dimensional charging simulations were performed for eclipse and sunlight conditions, with various plasma environments. The importance of three-dimensional effects is demonstrated. Differential charging on the solar arrays during eclipse and immediately following eclipse are predicted to be significant. Charging is strongly dependent on exposed material parameter values, since these determine the magnitudes of the seven basic components of the current to a surface. The effects of changes in the properties of exposed materials on the charging of the satellite were investigated to identify ways of reducing the differential charging. The associated program MATCHG was also used to investigate material response to charging environments (including laboratory electron beams) at a more basic level, without consideration of the geometrical or photoemission effects. It proves a useful tool in aiding the interpretation and reconciliation of material testing results before a full NASCAP run is undertaken. ESA

N88-25394*# Alabama Univ., Huntsville. Dept. of Electrical and Computer Engineering.
SPACE STATION INDUCED ELECTROMAGNETIC EFFECTS
N. SINGH *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 31-42 May 1988
Avail: NTIS HC A07/MF A01 CSCL 20N

Several mechanisms which can cause electric (E) and magnetic (B) field contaminations of the Space Station environment are identified. The level of E and B fields generated by some of them such as the motion of the vehicle across the ambient magnetic field B(0) and the 20-kHz leakage currents and charges can be controlled by proper design considerations. On the other hand, there are some mechanisms which are inherent to the interaction of large vehicles with the plasma and probably their contributions to E and B fields cannot be controlled: these include plasma waves in the wake and ram directions and the effects of the volume current generated by the ionization of neutrals. The interaction of high-voltage solar arrays with plasma is yet another rich source of E and B fields and it is probably uncontrollable. Wherever possible, quantitative estimates of E and B are given. A set of recommendations is included for further study in areas where indepth knowledge is seriously lacking. Author

N88-25745*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE ANTENNA EXPERIMENTS ABOARD THE SPACE SHUTTLE: APPLICATION OF NONUNIFORM SAMPLING TECHNIQUES
Y. RAHMATSAMII *In its* Proceedings of the Mobile Satellite Conference p 459-464 May 1988
Avail: NTIS HC A23/MF A01 CSCL 17B

Future satellite communication and scientific spacecraft will utilize antennas with dimensions as large as 20 meters. In order to commercially use these large, low sidelobe and multiple beam antennas, a high level of confidence must be established as to their performance in the 0-g and space environment. Furthermore, it will be desirable to demonstrate the applicability of surface compensation techniques for slowly varying surface distortions which could result from thermal effects. An overview of recent advances in performing RF measurements on large antennas is presented with emphasis given to the application of a space based far-field range utilizing the Space Shuttle and the concept of a newly developed nonuniform sampling technique. Author

N88-25746*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE 15-METER ANTENNA PERFORMANCE OPTIMIZATION USING AN INTERDISCIPLINARY APPROACH
WILLIAM L. GRANTHAM, LYLE C. SCHROEDER, MARION C. BAILEY, and THOMAS G. CAMPBELL *In* Jet Propulsion Lab., Proceedings of the Mobile Satellite Conference p 465-470 May 1988
Avail: NTIS HC A23/MF A01 CSCL 17B

A 15-meter diameter deployable antenna has been built and is being used as an experimental test system with which to develop interdisciplinary controls, structures, and electromagnetics technology for large space antennas. The program objective is to study interdisciplinary issues important in optimizing large space antenna performance for a variety of potential users. The 15-meter antenna utilizes a hoop column structural concept with a gold-plated molybdenum mesh reflector. One feature of the design is the use of adjustable control cables to improve the paraboloid reflector shape. Manual adjustment of the cords after initial deployment improved surface smoothness relative to the build accuracy from 0.140 in. RMS to 0.070 in. Preliminary structural dynamics tests and near-field electromagnetic tests were made. The antenna is now being modified for further testing. Modifications include addition of a precise motorized control cord adjustment system to make the reflector surface smoother and an adaptive feed for electronic compensation of reflector surface distortions. Although the previous test results show good agreement between calculated and measured values, additional work is needed to study modelling limits for each discipline, evaluate the potential of adaptive feed compensation, and study closed-loop control performance in a dynamic environment. Author

N88-26396# Aerospace Corp., El Segundo, CA. Space Sciences Lab.
A SEVERE SPACECRAFT-CHARGING EVENT ON SCATHA IN SEPTEMBER 1982
H. C. KOONS, P. F. MIZERA, J. L. ROEDER, and J. F. FENNELL 5 Feb. 1988 30 p
(Contract F04701-85-C-0086)
(AD-A193007; TR-0086A(2940-06)-6; SD-TR-88-12) Avail: NTIS HC A03/MF A01 CSCL 22B

On September 22, 1982, 29 large amplitude electrostatic discharges were detected by the Pulse Analyzer onboard the SCATHA satellite. Seventeen of these pulses exceeded the maximum voltage discrimination level, which was set to 7.4 volts. This was the worst instance of electrostatic discharges encountered to date by the SCATHA satellite. Three different spacecraft anomalies occurred on SCATHA that day, the most serious being a two-minute loss of data. During this same time period, the Surface Potential Monitor experiment aboard the satellite measured the largest differential surface charging observed in the data since the satellite's launch in January 1979. GRA

N88-29375*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
EXPERT SYSTEMS FOR MSFC POWER SYSTEMS

DAVID J. WEEKS *In its* Second Conference on Artificial Intelligence for Space Applications p 215-226 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 10B

Future space vehicles and platforms including Space Station will possess complex power systems. These systems will require a high level of autonomous operation to allow the crew to concentrate on mission activities and to limit the number of ground support personnel to a reasonable number. The Electrical Power Branch at NASA-Marshall is developing advanced automation approaches which will enable the necessary levels of autonomy. These approaches include the utilization of knowledge based or expert systems. Author

N88-29412*# Rockwell International Corp., Canoga Park, CA. Rocketdyne Div.
UTILIZATION OF ARTIFICIAL INTELLIGENCE TECHNIQUES FOR THE SPACE STATION POWER SYSTEM
THOMAS C. EVATT and EDWARD W. GHOLDSTON *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 555-562 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

Due to the complexity of the Space Station Electrical Power System (EPS) as currently envisioned, artificial intelligence/expert system techniques are being investigated to automate operations, maintenance, and diagnostic functions. A study was conducted to investigate this technology as it applies to failure detection, isolation, and reconfiguration (FDIR) and health monitoring of power system components and of the total system. Control system utilization of expert systems for load scheduling and shedding operations was also researched. A discussion of the utilization of artificial intelligence/expert systems for Initial Operating Capability (IOC) for the Space Station effort is presented along with future plans at Rocketdyne for the utilization of this technology for enhanced Space Station power capability. Author

N88-30182# AEG-Telefunken, Wedel (Germany, F.R.). Space and New Technologies Subdivision.
ALTERNATIVE MODULE CONFIGURATIONS FOR ADVANCED SOLAR ARRAYS ON LOW ORBIT AND EXTENDED LIFETIME MISSIONS (AMOC 2) Final Report
D. GRINGEL, U. HOFFMANN, J. KOCH, F. REISSMANN, and W. SCHMITZ Paris, France ESA 15 Dec. 1987 116 p
(Contract ESTEC-5508/83-NL-PB(SC))
(ESA-CR(P)-2581; ETN-88-93026) Avail: NTIS HC A06/MF A01

The applicability of the bifacial solar cell for generators operating in the low earth orbit and having extended life time mission was studied. Two candidate module concepts for flexible roll out and/or fold out solar generator systems were defined. One module concept is characterized by a continuous light transparent substrate and uses a transparent adhesive to glue the solar cells onto the substrate. The other module concept uses a nontransparent substrate with cutouts (windows) in the solar cell area of the substrate so that only small rearside areas of the individual solar cells are covered. The design and the bifacial solar cell technology were improved with regard to their applicability for larger assemblies. A thermal vacuum cycling test on a foldable ATOX resistant window type solar panel assembly confirms design feasibility. ESA

N88-30501# Joint Publications Research Service, Arlington, VA.
RELATIONSHIP BETWEEN CHARACTERISTICS OF LOW-ENERGY ELECTRONS AND GEOMAGNETIC DISTURBANCE IN GEOSTATIONARY ORBIT Abstract Only
O. S. GRAFODATSKIY, V. I. DEGTYAREV, A. G. KOZLOV, V. I. LAZAREV, O. I. PLATONOV, G. V. POPOV, and M. V. TELTSOV *In its* JPRS Report: Science and Technology. USSR: Space p 12-13 26 Feb. 1988 Transl. into ENGLISH from Geomagnetizm i Aeronomiya (Moscow, USSR), v. 27, no. 3, May - Jun. 1987 p 494-496
Avail: NTIS HC A04/MF A01

Measurements of low-energy (0.3 to 5.0 keV) electrons made on the Raduga geostationary satellite during a period of low magnetospheric disturbance in April-September 1980 are analyzed. The spectra of particles in the substorm disturbance region differ from Maxwellian and their fluxes are increased as a result of acceleration of plasma sheet particles from the tail of the magnetosphere in the region 6.6 R sub E. The fluxes and spectra of these particles are complexly and strongly dependent on the level of magnetic disturbance and LT. In order to ascertain the relationship between the observed spectra and the physical processes in the magnetosphere it was assumed that a magnetosphereic distrubance develops in a spatially limited nucleus near the midnight meridian and in its expansion forms the charged particles injection front. The results of measurements of electron fluxes were averaged for fixed hourly LT intervals and the diurnal variations of fluxes of electrons of different energies was determined from these averaged values. The effects of local magnetospheric disturbances and the effects of movements of the plasma sheet edge could be separated. In a particularly quiet magnetosphere there were no regions in the neighborhood of the geostationary orbit where electron acceleration could occur; in the quiet magnetosphere small local disturbances can occur; in a slightly disturbed magnetosphere the frequency and intensity of local disturbances increase. Author

07

ADVANCED MATERIALS

Includes matrix composites, polyimide films, thermal control coatings, bonding agents, antenna components, manufacturing techniques, and space environmental effects on materials.

A88-33018
DESIGN, FABRICATION, AND TESTING OF ROLLED CARBON/EPOXY STRUTS FOR SPACE STATION APPLICATION
RUDY LUKEZ, DAVID R. NELSON (Morton Thiokol, Inc., Brigham City, UT), VOLKER B. TELLER, and HARLEY J. ROCKOFF (Rockwell International Corp., Space Station Systems Div., Downey, CA) IN: International SAMPE Technical Conference, 19th, Crystal City, VA, Oct. 13-15, 1987, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 536-544.

High-quality carbon/epoxy struts applicable to the proposed NASA Space Station's space structure in virtue of their high stiffness, low voids-content, and low production cost, have been manufactured by means of a novel 'tape-rolling' process. In this process, aluminum foil overwraps serving as protection for the epoxy in the space environment can be easily incorporated. Alternative fabrication methods which were considered and rejected include filament-winding, braiding, and pultrusion. O.C.

A88-33958
ELECTROTOPOGRAPHIC INVESTIGATION OF THE DEGRADATION DYNAMICS OF DIELECTRIC LAYERS IN SPACE [ELEKTROTOPOGRAFICHESKIE ISSLEDOVANIIA DINAMIKI DEGRADATSII DIELEKTRICHESKIKH SLOEV V OTKRYTOM KOSMOSE]
A. E. KRAVTSOV and M. T. SHPAK (AN USSR, Institut Fiziki, Kiev, Ukrainian SSR) Kosmicheskaia Nauka i Tekhnika (ISSN 0321-4508), no. 1, 1986, p. 69, 70. In Russian. refs

The necessity of collecting data on the degradation of spacecraft structural materials under the effects of space flight factors is substantiated. A technique for the electrotopographic monitoring of defects is described. Results are presented on the degradation dynamics of thin dielectric layers under the effect of space flight factors investigated in the Salyut-7 Electrotopograph experiments. B.J.

A88-34312* Spectrolab, Inc., Sylmar, CA.
DEVELOPMENT OF 8 CM X 8 CM SILICON GRIDDED BACK SOLAR CELL FOR SPACE STATION

D. R. LILLINGTON, J. R. KUKULKA, S. M. BUNYAN, G. F. J. GARLICK (Spectrolab, Inc., Sylmar, CA), and B. SATER (NASA, Lewis Research Center, Cleveland, OH) IN: IEEE Photovoltaic Specialists Conference, 19th, New Orleans, LA, May 4-8, 1987, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 489-493.
(Contract NAS3-24672)

The 8-cm x 8-cm gridded back cell being developed for the space station photovoltaic array is described. Modeling studies show that the beginning of life power output of 1.039 W per cell may be met by several different configurations, the most promising being either a fielded or nonfielded 2 ohm-cm planar 8-mil cell. Experimental data are presented which show that a thermal alpha of 0.63 is achievable on a planar cell but at the expense of some Isc. Planar cells are found to possess short-circuit currents which are 9 percent lower than on textured cells due to the loss of near-IR radiation by transmission through the cell. Preliminary modeling shows that the efficiency of the textured cell exceeds the planar cell by approximately 9 percent at 25 C but the situation is reversed in orbit due to the high thermal alpha of textured cells (0.82). Experimental data show that the IR absorption in textured cells can be reduced by about 3 alpha points without loss of efficiency by controlling the doping concentration in the diffused layers, thus increasing the efficiency in orbit. I.E.

A88-34418* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

TEMPERATURE CHARACTERISTICS OF SILICON SPACE SOLAR CELLS AND UNDERLYING PARAMETERS

B. E. ANSPAUGH, RAM KACHARE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and G. F. J. GARLICK IN: IEEE Photovoltaic Specialists Conference, 19th, New Orleans, LA, May 4-8, 1987, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1194-1200. refs

Silicon space cells, 2 cm x 2 cm, with 10 ohm-cm p-base resistivity, 8-mil base thickness, and no back-surface fields have been investigated over the temperature range from 301 to 223 K by measurements of dark forward and reverse current-voltage characteristics and current-voltage relations under illumination. From dark forward bias data, the first and second diode saturation currents, I01 and I02, are determined and hence the base diffusion length and lifetime of minority carriers as functions of temperature. Lifetime increases exponentially with temperature and is explained by a Shockley-Read-Hall model with deep recombination levels 0.245 eV above the valence band. The I02 variation with temperature follows the Sah-Noyce-Shockley-Choo model except at low temperature where extra transitions raise the value above the predicted level. Reverse bias current at low voltage is a thermally assisted tunneling process via deep levels which are observed in base recombination at higher temperatures. The tunneling effects tend to become independent of temperature in the low-temperature region. These results demonstrate the ability to deduce basic parameters such as lifetime from simple measurements and show that back-surface fields offer no advantage at temperatures below 230 K. The analysis also explains the fall in lifetimes observed as the base conductivity increases, attributing it to native defects (perhaps carbon-oxygen-vacancy complexes) rather than the concentration of base dopant. I.E.

A88-34448

FLIGHT QUALIFICATION TESTING OF ULTRATHIN SOLAR CELLS

R. D. WILLIAMS, S. W. GELB, L. J. GOLDHAMMER, and G. S. GOODELLE (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA) IN: IEEE Photovoltaic Specialists Conference, 19th, New Orleans, LA, May 4-8, 1987, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1490, 1491.

Characterization and flight qualification testing has been conducted on ultrathin (0.0025-inch) production solar cells. Cells qualified by this test program and subsequently used in the fabrication of a Hughes HS 376 communications satellite represent the first ultrathin production solar cells to be used as the primary power source of a commercial satellite. Systems tests conducted on that satellite, including the solar panel, recently have been successfully completed. Significant results of the testing included verification of the mechanical integrity of the ultrathin solar cell and confirmation of improved radiation hardness. Improved resistance to radiation degradation is most pronounced at lower fluences, however the superior current collection efficiency of the ultrathin cell design is maintained in significant degree throughout the lifetime of a typical 10-year geosynchronous mission. I.E.

A88-35565* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

TRIBOLOGICAL PROPERTIES OF POLYMER FILMS AND SOLID BODIES IN A VACUUM ENVIRONMENT

ROBERT L. FUSARO (NASA, Lewis Research Center, Cleveland, OH) STLE Tribology Transactions (ISSN 0569-8197), vol. 31, April 1988, p. 174-180; Discussion, p. 181. Previously announced in STAR as N87-17906. refs

The tribological properties of ten different polymer based materials were evaluated in a vacuum environment to determine their suitability for possible lubrication applications in a space environment, such as might be encountered on the proposed Space Station. A pin-on-disk tribometer was used and the polymer materials were evaluated either as solid body disks or as films applied to 440C HT stainless steel disks. A 440C HT stainless steel hemispherically tipped pin was slid against the polymer materials. For comparison, similar tests were conducted in a controlled air atmosphere of 50 percent relative humidity air. In most instances, the polymer materials lubricated much better under vacuum conditions than in air. Thus, several of the materials show promise as lubricants for vacuum applications. Friction coefficients of 0.05 or less and polymer material wear rates of up to 2 orders of magnitude less than in air were obtained. One material showed considerable promise as a traction drive material. Relative high friction coefficients (0.36 to 0.52) and reasonably low wear rates were obtained in vacuum. Author

A88-35945*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

MAST MATERIAL TEST PROGRAM (MAMATEP)

MICHAEL L. CIANCONE and SHARON K. RUTLEDGE (NASA, Lewis Research Center, Cleveland, OH) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 12 p. refs
(AIAA PAPER 88-2475)

The MAMATEP program, which is aimed at verifying the need for and evaluating the performance of various protection techniques for the solar array assembly mast of the Space Station photovoltaic power module, is discussed. Coated and uncoated mast material samples have been environmentally tested and evaluated, before and after testing, in terms of mass and bending modulus. The protective coatings include CV-1144 silicone, a Ni/Al/InSn eutectic, and an open-weave Al braid. Long-term plasma asher results from unprotected samples indicate that, even though fiberglass-epoxy samples degrade, a protection technique may not be necessary to ensure structural integrity. A protection technique, however, may be desirable to limit or contain the amount of debris generated by the degradation of the fiberglass-epoxy. V.L.

A88-36762*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

DEGRADATION OF GRAPHITE-EPOXY DUE TO ELECTRON RADIATION

C. T. HERAKOVICH, D. J. FOX (Virginia Polytechnic Institute and State University, Blacksburg), and G. F. SYKES (NASA, Langley Research Center, Hampton, VA) ASME, Transactions, Journal of Engineering Materials and Technology (ISSN 0094-4289), vol. 110, April 1988, p. 146-152. refs
(Contract NAG1-343)

Experimental results are presented showing that electron irradiation has a variable effect on the properties of graphite-epoxy depending upon the test temperature and the property of interest.

In general, compression properties are improved at cold temperature and degraded at elevated temperature. With the exception of some moduli, tensile and shear properties are degraded at both cold and elevated temperatures. Electron irradiation lowers the glass transition temperature of graphite/epoxy significantly. Property degradation of irradiated materials at the elevated temperature is associated with the reduction in Tg. It is shown that a (0) compression-strength test is the most sensitive test for exhibiting the effects of electron irradiation. Results from tests on neat resin also show that the bulk matrix is degraded after irradiation, and that the correlation between resin and composite response is good. Author

A88-36982

MEASUREMENTS OF THERMAL CONDUCTIVITY AND THERMAL CONTACT RESISTANCE IN COMPOSITE MATERIALS FOR SPACE APPLICATIONS

M. GIOMMI, F. R. TORRISI (Selenia Spazio S.p.A., Rome, Italy), M. MARCHETTI, and P. TESTA (Roma I, Universita, Rome, Italy) IN: International Conference on Composite Materials, 6th, and European Conference on Composite Materials, 2nd, London, England, July 20-24, 1987, Proceedings. Volume 4. London and New York, Elsevier Applied Science, 1987, p. 4.323-4.334. refs

In the study reported here, a specially designed apparatus was used to measure the thermal conductivity and thermal contact resistance of stainless steel, aluminum, copper, and glass/epoxy and carbon/epoxy composites at pressures up to 28 x 10 to the 6th Pa in the temperature range 30-90 C. The thermal conductivity of the composites tested is found to be essentially independent of the applied pressure; in the range studied, temperature does not play an important role. Thermal contact conductance, however is found to increase with the applied load. V.L.

A88-37000

DAMPING MATERIALS FOR SPACECRAFT VIBRATION CONTROL

JUN FUJIMOTO, RYOSUKE UGO (NEC Corp., Kawasaki, Japan), YOHZOH YAMAMOTO (Mitsui Petrochemical Research Center, Ichihara, Japan), and KAZUHIDE TODOME (NEC Corp., Space Development Div., Yokohama, Japan) IN: International Conference on Composite Materials, 6th, and European Conference on Composite Materials, 2nd, London, England, July 20-24, 1987, Proceedings. Volume 5. London and New York, Elsevier Applied Science, 1987, p. 5.134-5.143. refs

Newly developed constrained shear damping materials for spacecraft vibration control are epoxy based polymers. These materials show high damping capability (tan delta max = 1.3-1.8) and have low outgassing (TML less than 1 percent) in a space environment. Damping material SS-37 was applied to the 'Yo-Yo' bracket in the 11th scientific satellite ASTRO-C (Japan). Author

A88-37293#

SOLAR-DYNAMIC ENERGY SUPPLY SYSTEMS FOR SPACE SYSTEMS

ALBERT FRITZSCHE and WOLF-JUERGEN DENNER Dornier-Post (English Edition) (ISSN 0012-5563), no. 1, 1988, p. 41-43.

Solar-dynamic spacecraft power-supply systems combine technically known processes of terrestrial power supply systems with a primary solar energy collector suitable for the 1.37 kW/sq m-intensity solar flux. An autonomous solar-dynamic module will encompass a parabolic solar collector, a receiver cavity for heat transfer to a working fluid, a thermal storage system, a thermomechanical converter, a cooler/preheater for use of waste heat, a radiator, an electrical generator, an energy conditioning system, and heliostatic mechanisms for pointing the concentrator. O.C.

A88-37343

REFILLING PROCESS IN THE PLASMASPHERE AND ITS RELATION TO MAGNETIC ACTIVITY

XIAO-TING SONG, ROGER GENDRIN, and GERARD CAUDAL (Centre de Recherches en Physique de l'Environnement Terrestre et Planetaire, Issy-les-Moulineaux, France) Journal of Atmospheric and Terrestrial Physics (ISSN 0021-9169), vol. 50, March 1988, p. 185-195. refs

Plasma density data obtained by the GEOS-2 satellite are used to study the refilling process in the plasmasphere and the relationship between the refilling process and magnetic activity (the Dst index). The average refilling rate of about 25/cu cm per day experimentally deduced for small absolute values of Dst is found to agree well with the corresponding refilling rate predicted using the theory of Lamaire (1985). It is suggested that the observed correlation of refilling rate with Dst index results from the modification of the composition of the topside ionosphere occurring after intense storms. R.R.

A88-37466

USE OF MODAL ENERGY DISTRIBUTION IN THE DESIGN OF HONEYCOMB SANDWICH DECKS

M. SAMBASIVA RAO, P. S. NAIR (Indian Space Research Organization, Satellite Centre, Bangalore, India), and S. DURVASULA (Indian Institute of Science, Bangalore, India) Computers and Structures (ISSN 0045-7949), vol. 28, no. 6, 1988, p. 737-743. refs

Through the example of a spacecraft equipment deck, which is generally made of honeycomb sandwich construction, it is shown that modal energy distribution can be used as an effective guideline in improving the deck's frequencies to meet the restrictions imposed upon it. The kinetic energy distribution is employed as a basis for redistributing various packages on the deck. Strain energy distribution is used to identify areas which can be stiffened by bonding 'doublers' on the face sheets and the doubler thickness is obtained from a sensitivity analysis. Author

A88-38015

'SPACE WEATHER FORECAST' - PREDICTION OF RELATIVISTIC ELECTRON INTENSITY AT SYNCHRONOUS ORBIT

TSUGUNOBU NAGAI (Meteorological Research Institute, Tsukuba, Japan) Geophysical Research Letters (ISSN 0094-8276), vol. 15, May 1988, p. 425-428. refs

Long-term variations in high-energy (greater than 2 MeV) electron flux at synchronous orbit are examined to reveal their close relationship to geomagnetic activity. The electron flux diminishes rapidly in association with an enhancement of geomagnetic activity (storm) and then increases. The flux becomes higher than the pre-storm level and its peak occurs approximately 4-5 days after the enhancement of geomagnetic activity. A linear prediction filter is designed for daily sums of Kp as input data and corresponding daily averages of the electron flux (Log value) as output data. The data are those taken in 1984-1985. This filter can successfully reproduce the electron flux behavior observed not only in 1984-1985 but also in 1978-1981. Author

A88-40568

PROSPECTS OF INTERCALATED GRAPHITE FIBRE USE FOR ELECTRICAL POWER TRANSMISSION IN SOLAR POWER SATELLITES

SERGE FLANDROIS, CLAUDE MESCHI, and PIERRE DELHAES (CNRS, Centre de Recherche Paul Pascal, Talence, France) Space Power (ISSN 0951-5089), vol. 7, no. 1, 1988, p. 51-56. Research supported by Electricite de France. refs

The properties of different-source carbon fibers which can be used for intercalation with metal chlorides are discussed together with the characteristics (relevant for electrical power transmission) of various intercalated fibers. Special attention is given to the experimental results obtained on graphite fibers intercalated with $CuCl_2$, $AlCl_3$, $InCl_3$, $GaCl_3$, $SbCl_5$, $CdCl_2$, and $PdCl_2$. The products were characterized by SEM, Raman microprobe spectroscopy, and X-ray diffraction, in addition to electrical resistivity measurements, stress-strain traction experiments, and current density tests. The conductivity losses were determined in air and high vacuum at temperatures below 200 C. The results showed that the electrical conductivity of intercalated graphite fibers is below that of Al and Cu. It is considered however that, owing to their superior stability, low density, and good mechanical properties, intercalated carbon fibers have good prospects for power transmission, particularly in solar power satellites. I.S.

A88-41547* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SPACE RADIATION EFFECTS ON POLY(ARYL-ETHER-KETONE) THIN FILMS AND COMPOSITES

JOAN G. FUNK (NASA, Langley Research Center, Hampton, VA) and GEORGE F. SYKES, JR. SAMPE Quarterly (ISSN 0036-0821), vol. 19, April 1988, p. 19-26. refs

The purpose of this study was to assess the space durability of poly(aryl-ether-ketone) (PEEK) in the forms of films and graphite fiber reinforced composites. The influence of the film's crystallinity on electron radiation stability was evaluated using X-ray diffraction, DSC, FTIR, and mechanical property tests. The mechanical properties of the composites material were evaluated after electron radiation and after electron radiation followed by thermal cycling simulating 30 years in geosynchronous orbit. Author

A88-41885

MANUFACTURING OF DAMAGE-RESISTANT COMPOSITE STRUCTURES FOR AEROSPACE APPLICATIONS

ASHOK K. MUNJAL (Aerojet Strategic Propulsion Co., Sacramento, CA) IN: Advanced composites III: Expanding the technology; Proceedings of the Third Annual Conference, Detroit, MI, Sept. 15-17, 1987. Metals Park, OH, ASM International, 1987, p. 53-56. refs

The present discussion of emerging manufacturing methods for the production of damage-resistant composite structures addresses impact, fatigue, and creep damage resistance effects obtainable by identifiable design, materials formulation, and fabrication practices. Damage containment methods encompass stitching of layup plies, interleafing, three-dimensional reinforcements, hybrid materials, and the incorporation of external protection materials. Attention is given to the effects of strength, modulus, strain-to-failure, fracture toughness, and resistance to environmental temperature and humidity. O.C.

A88-42372

A TECHNIQUE TO EVALUATE COATINGS FOR ATOMIC OXYGEN RESISTANCE

J. B. CROSS (Los Alamos National Laboratory, NM), E. H. LAN, and C. A. SMITH (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 693-702. refs

Space Shuttle flight data has shown that the LEO environment significantly degrades a variety of spacecraft materials. Atomic oxygen, the major constituent of the LEO atmosphere, is primarily responsible for the degradation due to its oxidative ability, high collision energy (approximately 5 eV for a spacecraft traveling at 8 km/sec), and high flux. Atomic oxygen-reactive materials to be used on long-term spacecraft such as Space Station must be coated with an oxygen-resistant coating if they are to survive in LEO for an extended period of time. A technique using oxidation of silver film as an atomic oxygen detector has been developed to evaluate the effectiveness of coatings in protecting substrates which react with atomic oxygen. The paper discusses results from a bare silver and a PTFE Teflon-coated silver sample which show that this technique is viable for detecting atomic oxygen penetration through coatings. A discussion of the advantages and disadvantages of the technique is included. Author

A88-42412* Boeing Aerospace Co., Seattle, WA.

EVALUATION OF CHROMIC ACID ANODIZED ALUMINUM FOIL COATED COMPOSITE TUBES FOR THE SPACE STATION TRUSS STRUCTURE

HARRY W. DURSCH (Boeing Aerospace Co., Seattle, WA) and WAYNE S. SLEMP (NASA, Langley Research Center, Hampton, VA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1342-1354. refs

This paper describes the development and evaluation of chromic acid anodized (CAA) Al foil as a protective and thermal control coating for graphite/epoxy tubes designed for the Space Station truss structure. Special consideration is given to the development of solar-absorptance and thermal-emittance properties required of Al foil, the development of CAA parameters necessary to achieve these optical properties, and the atomic oxygen and UV testing of CAA Al foil. Results showed that 0.003-in CAA Al foil cocured or secondary bonded to graphite/epoxy tubes with thin epoxy film adhesive retains excellent bond strength and provides a superior protective and thermal control coating to the LEO environment. Processes were developed for CAA Al foils long enough to continuously wrap the 23-ft-long diagonal struts of the Space Station truss structure. Specifications are presented for the processes of chromic acid anodizing of Al foil and for the bonding of anodized Al foil to graphite/epoxy tubes. I.S.

A88-42419

GRAPHITE THERMOPLASTIC COMPOSITES FOR SPACECRAFT APPLICATIONS

EDWARD M. SILVERMAN and ROBERT J. JONES (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1418-1432. refs

Spacecraft application evaluations encompassing dynamic mechanical analysis, flexural and transverse tensile strength, outgassing/condensable volatiles, equilibrium water absorption, damping capability, and the effect of 500 -250 to + 250 F thermal cycles on microcracking, have been conducted for both graphite/PEEK- and graphite/PPS-based prepreg tapes and comingled, bidirectional graphite/PEEK fabrics. SEM analysis results indicate that the higher level of mechanical properties of the PEEK composites may be due to better interfacial bonding than that obtainable with PPS. O.C.

A88-42434* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THERMAL CYCLING EFFECTS ON THE DIMENSIONAL STABILITY OF P75 AND P75-T300 (FABRIC) HYBRID GRAPHITE/EPOXY LAMINATES

DAVID E. BOWLES (NASA, Langley Research Center, Hampton, VA) and JAMES SHEN (PRC Kentron, Inc., Hampton, VA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1659-1671. refs

The response of cross-ply P75/934 laminates and hybrid laminates consisting of P75/934 unidirectional tape and T300/934 woven fabric were compared for temperature exposures between + and - 250 F up to a maximum of 250 cycles. The properties monitored included microcrack density, coefficient of thermal expansion (CTE), residual strain, and tensile modulus. Hybrid laminates, with stiffnesses and CTE's comparable to P75/934 cross-ply laminates, demonstrated significantly improved thermal cycling stability in one direction. The hybrid laminates also had predicted longitudinal properties comparable to low angle, off-axis P75/934 configurations, but had significantly higher predicted transverse strengths. T300 Gr/Ep plain-weave fabric laminates were shown to be much less susceptible to thermal cycling damage than T300 Gr/Ep cross-ply laminates. None of the laminates tested exhibited any significant changes in tensile modulus after thermal cycling. Author

A88-42440* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

QUALIFICATION OF ROOM-TEMPERATURE-CURING EPOXY ADHESIVES FOR SPACECRAFT STRUCTURAL APPLICATIONS

ALAIN CARPENTER and TIM O'DONNELL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1761-1772. refs

(Contract NAS7-918)

An adhesive-bonding test program is being conducted in order to develop structural adhesives applicable to JPL spacecraft. A noteworthy application for such an adhesive will be JPL's Galileo mission, whose trajectory will involve the circumnavigation of the planet Venus prior to Jupiter rendezvous, and will accordingly require stringent temperature and radiation environment requirements. The baseline adhesive for the test program is the EA 934 room temperature-cure epoxy, which has been widely used as a 'space-qualified' material. O.C.

A88-43516*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

DECISION TIME ON ORBITAL DEBRIS

JOSEPH P. LOFTUS (NASA, Johnson Space Center, Houston, TX), LEE E. TILTON (NASA, Washington, DC), and L. PARKER TEMPLE, III (USAF, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 26, June 1988, p. 16-18.

The problem of orbital debris, especially in LEO is discussed, stressing ways to minimize hazards caused by debris. There are over 7,000 objects making up 2.4 X 10 to the 6th kg of debris in LEO with velocities up to 7 km/sec. The least costly way of minimizing hazards from debris is to make spent rocket stages inert, to preclude failures after their useful life, by insuring that all residual propellants and pressurant gases are vented while the stage is still subject to command. A more costly option is the actively controlled deorbit of spent stages and spacecraft at the end of their useful mission life. The removal of inert stages or spacecraft is too costly to be practical. The least expensive methods of removal are deorbit for altitudes below 25,000 km and placing the object in earth-escape trajectory for objects at higher altitudes. NASA is developing a special radar to measure the existing small-particle debris and its changes over time, and international agreements are expected to set standards of operational practices to minimize debris. R.B.

A88-43517*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

PREDICTING DEBRIS

DONALD J. KESSLER (NASA, Johnson Space Center, Houston, TX) Aerospace America (ISSN 0740-722X), vol. 26, June 1988, p. 22-24.

The probable amount, sizes, and relative velocities of debris are discussed, giving examples of the damage caused by debris, and focusing on the use of mathematical models to forecast the debris environment and solar activity now and in the future. Most debris are within 2,000 km of the earth's surface. The average velocity of spacecraft-debris collisions varies from 9 km/sec at 30 degrees of inclination to 13 km/sec near polar orbits. Mathematical models predict a 5 percent per year increase in the large-fragment population, producing a small-fragment population increase of 10 percent per year until the year 2060, the time of critical density. A 10 percent increase in the large population would cause the critical density to be reached around 2025. R.B.

A88-43518*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

SHIELDING AGAINST DEBRIS

BURTON G. COUR-PALAIS (NASA, Johnson Space Center, Houston, TX) and SHERMAN L. AVANS (NASA, Marshall Space Flight Center, Huntsville, AL) Aerospace America (ISSN 0740-722X), vol. 26, June 1988, p. 24, 25.

The damage to spacecraft caused by debris and design of the Space Station to minimize damage from debris are discussed. Although current estimates of the debris environment show that fragments bigger than 2 cm are not likely to hit the Space Station, orbital debris from about 0.5 mm to 2 cm will pose a hazard, especially on brittle surfaces, such as glass. Spacesuits are being designed to reduce debris caused dangers to astronauts during EVA. About 5 cm of high-strength aluminum are needed to prevent penetration by a 1 cm piece of aluminum with a mass near 1.5 g colliding at 10 km/sec. Because aluminum bumpers have the drawback of metallic debris ejected outward after a hypervelocity collision, the use of nonmetallic materials for bumpers is being studied. Methods of reducing the weight and volume of the shield for the Space Station are also being researched. A space station habitation module using bumpers has a 99.6 percent chance of avoiding penetration during its lifetime. R.B.

A88-43765*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

PARTICLE ADHESION TO SURFACES UNDER VACUUM

JACK B. BARENGOLTZ (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 9 p. refs

(AIAA PAPER 88-2725)

The release of glass beads and standard dust from aluminum and glass substrates under centrifugation (simulating atmospheric pressure, low vacuum, and high vacuum conditions) was measured, with application to the estimation of contaminant particle release during spacecraft launch. For particles in the 10-100 micron range, dust was found to adhere more strongly than glass beads in all the cases considered. For most of the cases, dust and glass beads adhered more strongly to glass than to aluminum at all pressures. The adhesion force for dust on glass at 10 torr was shown to be as small as the value for dust on aluminum. R.R.

A88-44004#

WELDING IN SPACE - AN OVERVIEW

R. M. RIVETT (Edison Welding Institute, Columbus, OH) IN: Advanced topics in manufacturing technology: Product design, bioengineering; Proceedings of the Symposium, ASME Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987. New York, American Society of Mechanical Engineers, 1987, p. 73-77. refs

The fabrication and repair of structures in space will be an important part of any long-term plans to commercialize space. In this paper the alternative joining techniques for use in a space environment are reviewed and their limitations discussed. To date the bulk of the work has been conducted on electron beam welding, arc welding and brazing. However, with the exception of the Soviet program to develop a hand-held electron beam gun, this work has been limited in nature and has mainly studied the influence of micro-gravity and vacuum on the process and the properties of the weld pool. From a review of the published literature it would appear that joining technology has not progressed to the point that a large structure could be fabricated or repaired in space using welding techniques. Author

A88-45109*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

BEYOND SIMULATION

JOHN G. DAVIS, JR. and SIDNEY C. DIXON (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 26, July 1988, p. 38-40, 42.

The technological breakthroughs required for the development of fully reusable launch vehicles are reviewed, with a focus on advanced materials and structures. Current proposals favor LH2 as a fuel for both conventional dual-stage rockets, vertical-launch SSTO rockets, and horizontal-launch airbreathing SSTOs; hence large cryogenic tanks and thermal protection (for descent in rockets and ascent in airbreathers) are required. Consideration is given to structural alloys and composites; thermal-protection materials; propellant-tank insulation materials; the design of light but strong tanks, wings, nose caps, and airbreathing-engine structures; and the problem of hot boundary-layer gases. The need for more accurate and efficient design codes (including dynamic loads and aerothermoelasticity) and for better ground test facilities is stressed. T.K.

A88-45201

ALUMINUM-LITHIUM ALLOYS: DESIGN, DEVELOPMENT AND APPLICATION UPDATE; PROCEEDINGS OF THE SYMPOSIUM, LOS ANGELES, CA, MAR. 25, 26, 1987

RAMESH J. KAR, ED., SUPHAL P. AGRAWAL, ED. (Northrop Corp., Aircraft Div., Hawthorne, CA), and WILLIAM E. QUIST, ED. (Boeing Commercial Airplane Co., Seattle, WA) Symposium organized and sponsored by ASM International. Metals Park, OH, ASM International, 1988, 470 p. For individual items see A88-45202 to A88-45205.

The present conference on the development status of aluminum-lithium alloys for aerospace applications discussed topics in the availability of these alloys, their fatigue, fracture, and corrosion characteristics, their design criteria, and manufacturing techniques developed for them to date. Attention is given to developments in rapidly-solidified Al-Li alloys, the mechanisms of fatigue crack propagation in commercial Al-Li alloys, the effects of processing on Al-Li microstructures and fracture behavior, and Al-Li exfoliation and stress corrosion cracking behavior. Also discussed are design considerations for novel aerospace vehicle materials, critical Al-Li alloy design factors, the application of Al-Li alloys in naval aircraft, and the superplastic forming characteristics of Al-Li sheet alloys. O.C.

A88-45205

SUPERPLASTIC FORMING CHARACTERISTICS AND PROPERTIES OF ALUMINUM-LITHIUM SHEET ALLOYS

MICHAEL J. REYNOLDS (Superform USA, Inc., Riverside, CA), CONSTANCE A. HENSHALL, and JEFFREY WADSWORTH (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) IN: Aluminum-lithium alloys: Design, development and application update; Proceedings of the Symposium, Los Angeles, CA, Mar. 25, 26, 1987. Metals Park, OH, ASM International, 1988, p. 357, 359-365, 367-399. Research supported by the Lockheed Missiles and Space Co., Inc.

A process has been developed for ingots of the Al-Li alloy 2090 which imparts the requisite microstructure for superplastic forming. Attention is presently given to representative applications of the alloy and the results of aging studies aimed at determining the T6 condition of 2090 alloy components. No apparent correlation is found between the degree of thinning and the strength developed after aging; the aged alloy exhibits an ultimate tensile strength of 61.8 ksi, with 10.2 percent elongation. Microstructure appeared uniform in both the as-formed and aged conditions, and cavitation was minimal. O.C.

A88-46192#

MECHANICAL AND ELECTRICAL CHARACTERISTICS OF TIN WHISKERS WITH SPECIAL REFERENCE TO SPACECRAFT SYSTEMS

B. D. DUNN (ESA, Materials and Processes Div., Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 11, no. 4/vol. 12, no. 1, 1987/1988, p. 1-17. refs

Tin-whisker samples have been harvested from the surfaces of tin-plated parts from electronic equipment and subjected to laboratory tests. These whiskers were found to have a low strength (Young's modulus of 8.0-85 GPa and UTS of about 8 MPa). Whiskers with a diameter of 3 microns are capable of carrying a current flow of 32 mA. They remain undisturbed by subjection to either a wide vibration spectrum or to mechanical shocks reaching 200 g. Spark discharges have been shown to emanate from the sides and tips of tin whiskers in vacuum. Unwanted growths can severely jeopardize the reliability of spacecraft subsystems. Author

A88-47449

RECENT ADVANCES IN AEROSPACE REFRACTORY METAL ALLOYS

J. WADSWORTH, T. G. NIEH, and J. J. STEPHENS (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) International Materials Reviews (ISSN 0950-6608), vol. 33, no. 3, 1988, p. 131-150. Research supported by the Lockheed Independent Research and Development Program. refs

The development of refractory metal alloys for aerospace applications is discussed. While refractory metals are prime candidates for many high-temperature aerospace components due to their high melting points and inherent creep resistance, their use is often limited by poor room temperature properties, inadequate oxidation resistance at elevated temperatures, or difficulties associated with joining or welding. Current research on the development of creep resistant niobium and tantalum alloys that are inherently oxidation resistant is described. Examples of novel solid state joining developments in tungsten and molybdenum alloys below and above their recrystallization temperatures are provided. K.K.

A88-47966*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

OPTICAL ENVIRONMENT OF THE SPACELAB 1 MISSION

MARSHA R. TORR, J. K. OWENS (NASA, Marshall Space Flight Center, Huntsville, AL), and D. G. TORR (Alabama, University, Huntsville) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 125-131. refs

The passing of large orbital vehicles through the space environment often generates such emissions as glows on or near the vehicle surface and halos surrounding the vehicle. These induced emissions may affect observations made with the optical instrumentation carried by the vehicles. The glows' causative mechanisms appear to be a complex function of altitude, time in orbit, materials, insolation, and vehicular size and orientation. Attention is presently given to contamination environment data obtained for the instrument suite carried by the Spacelab 1 Space Shuttle mission. O.C.

A88-47969#

TWO-PHASE ALKALI-METAL EXPERIMENTS IN REDUCED GRAVITY

ZENEN I. ANTONIAK (Battelle Pacific Northwest Laboratory, Richland, WA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 146-155. refs (Contract DE-AC06-76RL-01830)

Future space missions envision the use of large nuclear reactors using either a single or a two-phase alkali-metal working fluid. The design and analysis of such reactors require state-of-the-art computer codes that can properly treat alkali-metal flow and heat transfer in a reduced-gravity environment. Current single and multiphase computer codes rely on the presence of gravity - in the fluid momentum equations, in defining their flow regimes, in specific two-phase flow models, or indirectly in the form of correlations obtained from tests conducted in a 1-g field. New flow regime maps, models, and correlations are required if the codes are to be successfully applied to reduced-gravity flow and heat transfer. A literature search of relevant experiments in reduced gravity is reported on here and reveals a paucity of data for such correlations. The few ongoing experiments in reduced gravity are noted. General plans are put forth for the reduced-gravity experiments that will have to be performed, at NASA facilities, with benign fluids. Data from the reduced-gravity experiments with innocuous fluids are to be combined with normal gravity data from the two-phase alkali-metal experiments. Calculations and analyses undertaken here give every expectation that the correlations developed from this data base will provide a valid representation of alkali-metal heat transfer and pressure drop in reduced gravity. Author

A88-47971*# Communications Research Centre, Ottawa (Ontario).

RESULTS OF APPARENT ATOMIC OXYGEN REACTIONS WITH SPACECRAFT MATERIALS DURING SHUTTLE FLIGHT STS-41G

D. G. ZIMCIK (CDC, Communications Research Centre, Ottawa, Canada) and C. R. MAAG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) (Shuttle Environment and Operations II Conference, Houston, TX, Nov. 13-15, 1985, Technical Papers, p. 181-189) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 162-168. Previously cited in issue 03, p. 268, Accession no. A86-14403. refs

A88-49260
RADIATION INSPECTION METHODS FOR COMPOSITES
T. S. JONES, D. POLANSKY, and H. BERGER (Industrial Quality, Inc., Gaithersburg, MD) NDT International (ISSN 0308-9126), vol. 21, Aug. 1988, p. 277-282. refs

Radiography and ultrasonics are the generally selected methods for nondestructive inspection of fiber-reinforced polymer composites used in high-performance applications such as aircraft and space structures. As a result of their application and adaptation in this field, both methods have taken on a number of new aspects. Some of the advances in radiographic inspection techniques are reviewed here, together with the various criteria affecting their use in a particular situation. Examples of composites radiography by several different methods are presented. Author

A88-49996
RESEARCH IN CERAMICS AT THE U.S. NAVAL RESEARCH LAB
DAVID LEWIS, III (U.S. Navy, Naval Research Laboratory, Washington, DC) American Ceramic Society Bulletin (ISSN 0002-7812), vol. 67, Aug. 1988, p. 1349-1356. Navy-supported research. refs

Since 1987, the USN Research Lab's Composites and Ceramics Branch has undertaken work on: (1) high-temperature ceramic-matrix composites, with a view to the formulation of material requirements, processing methods, and characterization techniques (especially in the area of composite interface control); (2) high T(c) ceramic superconductors; (3) the strengthening of ceramics with ordered voids; (4) superconducting delay lines; (5) improved piezoelectric ceramics for active and passive sonars; (6) ceramic fracture mechanics and failure analysis techniques; and (7) rapid solidification processing of materials. Extensive microphotographic illustrations of state-of-the-art materials are presented. O.C.

A88-52331* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TECHNOLOGIES FOR PROTECTION OF THE SPACE STATION POWER SYSTEM SURFACES IN ATOMIC OXYGEN ENVIRONMENT
HENRY K. NAHRA and SHARON K. RUTLEDGE (NASA, Lewis Research Center, Cleveland, OH) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-1 to 5-8. refs

Technologies for protecting Space Station surfaces from degradation caused by atomic oxygen are discussed, stressing protection of the power system surfaces. The Space Station power system is described and research concerning the solar array surfaces and radiator surfaces is examined. The possibility of coating the solar array sufaces with a sputter deposited thin film of silicon oxide containing small concentrations of polytetrafluoroethylene is presented. Hexamethyldisiloxane coating for these surfaces is also considered. For the radiator surfaces, possible coatings include silver teflon thermal coating and zinc orthotitanate. R.B.

A88-53126#
ADVANCED COMPOSITES FOR MAGELLAN SPACECRAFT
D. A. STANG (Martin Marietta Corp., Astronautics Group, Denver, CO) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 4 p.
(AIAA PAPER 88-3031)

Over 100 composite tubes were built for truss members for the Magellan spacecraft which is to orbit and radar-map the planet Venus. Materials used were unidirectional and woven E-glass, S-2 glass, high-strength high modulus graphite. All were used in the form of epoxy preimpregnated broadgoods. Tube diameters ranged from 1 to 4 inches, and tube construction ranged from five to 21 layers. All tubes were fabricated and cured on aluminum mandrels. Each truss member assembly was proofloaded in axial compression prior to final vehicle assembly. This presentation will focus on the design, fabrication, and testing of three of the graphite/epoxy tube configuration. Author

A88-54731
UNIQUE BONDING METHODS FOR SPACECRAFT
JOSEPH E. FOS, JR. (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: IEEE 1988 International Symposium on Electromagnetic Compatibility, Seattle, WA, Aug. 2-4, 1988, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 412-417.

Bonding requirements in general are discussed. The additional factors that are introduced for spacecraft bonding are examined and shown to require methods that are outside of normal bonding techniques. An electronic box in a spacecraft is used to illustrate the problems encountered. I.E.

A88-54988*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ATOMIC-OXYGEN DURABILITY OF IMPACT-DAMAGED SOLAR REFLECTORS
DANIEL A. GULINO (NASA, Lewis Research Center, Cleveland, OH) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, Jan.-Feb. 1988, p. 39-44. Previously cited in issue 08, p. 1062, Accession no. A87-22417. refs

A88-54990*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
VELOCITY DISTRIBUTIONS OF OXYGEN ATOMS INCIDENT ON SPACECRAFT SURFACES
P. N. PETERS, R. C. SISK (NASA, Marshall Space Flight Center, AL), and J. C. GREGORY (Alabama, University, Huntsville) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, Jan.-Feb. 1988, p. 53-58. refs
(Contract NAGW-823; NAS8-36645)

The angular distributions of oxygen atoms incident on surfaces in low earth orbit have been calculated for a number of ambient gas temperatures. Atom fluxes to surfaces were modeled by integrals over all permitted angles of incidence. Angles of incidence are limited by masking structures, and a number of types of mask were considered. Combustible surfaces exposed to the orbital atmosphere are heavily etched, creating profiles in mask shadows that are sensitive to ambient temperatures. The influence of the angular distributions on the characteristics of etched surfaces is discussed. Profiles measured for a September, 1983 flight were fitted to this model profile with a temperature of 750 + or - 50 K, which agrees with estimates based on solar activity at that time. Applications to sensing ambient temperatures and oxygen atom densities are discussed. Author

A88-55374#
A FRACTURE CONTROL PLAN FOR COMPOSITE SPACECRAFT STRUCTURES
C. K. H. DHARAN (California, University, Berkeley) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 8 p. refs
(IAF PAPER 88-282)

Composite spacecraft structures, which are generally designed for high stiffness and dimensional stability, are highly anisotropic and may have low transverse strength and be susceptible to delamination. Here, a fracture control plan for composite spacecraft structures is proposed which uses delamination fracture toughness as the criterion for catastrophic crack propagation and depends on the application of appropriate nondestructive evaluation techniques. The discussion is illustrated by experimental results obtained for graphite/epoxy and glass/epoxy composites. V.L.

N88-21250*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

SPACE STATION SOLAR CONCENTRATOR MATERIALS RESEARCH

DANIEL A. GULINO May 1988 15 p
(NASA-TM-100862; E-4074; NAS 1.15:100862) Avail: NTIS HC A03/MF A01 CSCL 10B

The Space Station will represent the first time that a solar dynamic power system will be used to generate electrical power in space. In a system such as this, sunlight is collected and focused by a solar concentrator onto the receiver of a heat engine which converts the energy into electricity. The concentrator must be capable of collecting and focusing as much of the incident sunlight as possible, and it must also withstand the atomic oxygen bombardment which occurs in low Earth orbit (LEO). This has led to the development of a system of thin film coatings applied to the concentrator facet surface in a chamber designed especially for this purpose. The system of thin film coatings employed gives both the necessary degree of reflectance and the required protection from the LEO atomic oxygen environment. Author

N88-22225# Joint Publications Research Service, Arlington, VA.

SOLAR CELL COVER GLASSES FOR SATELLITES

TOKIO KIMURA *In its* JPRS Report: Science and Technology. Japan p 31-37 3 Mar. 1988 Transl. into ENGLISH from Ceramics Japan (Tokyo, Japan), Apr. 1987 p 303-308
Avail: NTIS HC A05/MF A01

Since the world's first artificial satellite, Vostok 1, was launched in October 1957, many artificial satellites were launched for many purposes. It is not generally known that such satellites incorporate glass parts which play important roles. Such glass parts include the cover glasses for solar cell systems attached to satellites and the thermal control mirrors for the satellite proper. These glass parts are used to protect satellites from radiation and heat, enabling them to function properly in space where environmental severity is beyond the imagination. Cover glasses will be examined. First, the space environment will be described in connection with the use of cover glasses. Then, the purposes of using cover glasses and the functions required of them covered. Finally, the actual cover glasses are described and the cover glass reliability management explained. Author

N88-23265# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de la Resistance des Structures.

A NONLINEAR COMPUTATION FOR COMPOSITE STRUCTURES Final Report [UN MODULE DE CALCUL NON LINEAIRE POUR LES STRUCTURES COMPOSITES]

R. GIRARD Mar. 1987 40 p In FRENCH
(Contract DRET-86-34-001)
(ONERA-RT-15/3542-RY-062-R; ETN-88-92141) Avail: NTIS HC A03/MF A01

A procedure based on total Lagrangian implementation, where the nonlinear problem is solved numerically by increment and iteration (Newton method with load increments) is presented. The finite element model is general enough to allow the analysis of large structures built with composite materials. Algorithms and computation strategies are compared. ESA

N88-24754*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ARC-TEXTURED METAL SURFACES FOR HIGH THERMAL EMITTANCE SPACE RADIATORS

BRUCE A. BANKS, SHARON K. RUTLEDGE, MICHAEL J. MIRTICH, TRACY BEHREND, DEBORAH HOTES, MICHAEL KUSSMAUL, JENNIFER BARRY, CURTIS STIDHAM, THOMAS STUEBER, and FRANK DIFILIPPO (Case Western Reserve Univ., Cleveland, Ohio.) 1988 11 p Presented at the International Conference on Metallurgical Coatings, San Diego, Calif., 11-15 Apr. 1988; sponsored by the American Vacuum Society
(NASA-TM-100894; E-4135; NAS 1.15:100894) Avail: NTIS HC A03/MF A01 CSCL 11F

Carbon arc electrical discharges struck across the surfaces of metals such as Nb-1 percent Zr, alter the morphology to produce a high thermal emittance surface. Metal from the surface and carbon from the arc electrode vaporize during arcing, and then condense on the metal surface to produce a microscopically rough surface having a high thermal emittance. Quantitative spectral reflectance measurements from 0.33 to 15 microns were made on metal surfaces which were carbon arc treated in an inert gas environment. The resulting spectral reflectance data were then used to calculate thermal emittance as a function of temperature for various methods of arc treatment. The results of arc treatment on various metals are presented for both ac and dc arcs. Surface characterization data, including thermal emittance as a function of temperature, scanning electron microscopy, and atomic oxygen durability, are also presented. The ac arc texturing was found to increase the thermal emittance at 800 K from 0.05 to 0.70. Author

N88-25390*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A STUDY OF SPACE STATION CONTAMINATION EFFECTS

M. R. TORR, ed., J. F. SPANN, ed., and T. W. MOOREHEAD, ed. May 1988 141 p Workshop held in Hilton Head Island, S.C., 29-30 Oct. 1987 Sponsored by NASA, Washington
(NASA-CP-3002; M-586; NAS 1.55:3002) Avail: NTIS HC A07/MF A01 CSCL 22B

A workshop was held with the specific objective of reviewing the state-of-knowledge regarding Space Station contamination, the extent to which the various categories of contamination can be predicted, and the extent to which the predicted levels would interfere with onboard scientific investigations or space station functions. The papers presented at the workshop are compiled and address the following topics: natural environment, plasma electromagnetic environment, optical environment, particulate environment, spacecraft contamination, surface physics processes, laboratory experiments and vented chemicals/contaminants.

N88-25391*# Science and Engineering Associates, Inc., Englewood, CO.

NEUTRAL ENVIRONMENT FOR SPACE STATION

R. O. RANTANEN *In* NASA, Langley Research Center, A Study of Space Space Station Contamination Effects p 1-9 May 1988
Avail: NTIS HC A07/MF A01 CSCL 22B

The results of studies to determine the contamination compatibility of the cross boom and dual keel Space Station configurations with attached payloads are presented. The approach was to define the 3-D configuration of the Space Station and calculate surface-to-surface view factors and solid angles between surfaces and points in an extensive point matrix around the Space Station via a modified TRASYS model. The molecular number column densities along specific experiment lines-of-sight on the cross boom generally meet JSC 30426 requirements. The deposition of contaminants on payload surfaces exceeds the JSC 30426 requirements. These model predictions require updating because of the impact on background brightness predictions. An increase of a factor of 2 to 10 in column densities would result in an unacceptable optical background. Author

N88-25392*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

SPACE STATION NEUTRAL EXTERNAL ENVIRONMENT

H. EHLERS and L. LEGER *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 11-17 May 1988
Avail: NTIS HC A07/MF A01 CSCL 22B

Molecular contamination levels arising from the external induced neutral environment of the Space Station (Phase 1 configuration) were calculated using the MOLFLUX model. Predicted molecular column densities and deposition rates generally meet the Space Station contamination requirements. In the doubtful cases of deposition due to materials outgassing, proper material selection, generally excluding organic products exposed to the external environment, must be considered to meet contamination requirements. It is important that the Space Station configuration, once defined, is not significantly modified to avoid introducing new unacceptable contamination sources. Author

N88-25393*# Iowa Univ., Iowa City. Dept. of Physics and Astronomy.

CONTAMINANT IONS AND WAVES IN THE SPACE STATION ENVIRONMENT

G. B. MURPHY *In* NASA, Langley Research Center, A Study of Space Space Station Contamination Effects p 19-29 May 1988

Avail: NTIS HC A07/MF A01 CSCL 22B

The probable plasma (ions and electrons) and plasma wave environment that will exist in the vicinity of the Space Station and how this environment may affect the operation of proposed experiments are discussed. Differences between quiescent operational periods and non-operational periods are also addressed. Areas which need further work are identified and a course of action suggested. Author

N88-25395*# Alabama Univ., Huntsville. Center for Space Plasma and Aeronomic Research.

SPACE STATION CONTAMINATION STUDY: ASSESSMENT OF CONTAMINANT SPECTRAL BRIGHTNESS

D. G. TORR *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 43-59 May 1988

Avail: NTIS HC A07/MF A01 CSCL 22B

The assessment of spectral brightness resulting from the ambient-contaminant interaction requires a knowledge of the details of cross sections and excitation mechanisms. The approach adopted was to utilize the spectral brightness measurements made on Spacelab 1 and on the S3-4 spacecraft to identify source mechanisms, key cross sections and hence, the abundance of contaminant species. These inferred abundances were then used to update the composition comprising the total column concentrations predicted by the Science and Engineering Associates' configuration contamination model for the Space Station and to scale the irradiances to four altitudes: 300, 350, 400, and 463 km. The concentration irradiances are compared with zodiacal natural background levels. The results demonstrate that emissive contamination is significantly more severe than anticipated. It is shown that spectral emissions can become competitive with the zodiacal background up to altitudes as high as 400 km for the vacuum ultraviolet and visible emissions. M.G.

N88-25396*# Physical Sciences, Inc., Andover, MA.

CALCULATION OF SPACE STATION INFRARED IRRADIANCE FROM ATMOSPHERE-INDUCED EMISSIONS

M. E. FRASER, A. GELB, B. D. GREEN, and D. G. TORR (Alabama Univ., Huntsville.) *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 61-69 May 1988

(Contract NAGW-922)

Avail: NTIS HC A07/MF A01 CSCL 22B

The excitation mechanisms and radiance estimates over the 1 to 10 micron region for CO2(v), H2O(v), CO(v), OH(v), NO2(2B-2A) and N2(B3 pi - A3 sigma) are discussed. The infrared irradiance of the Space Station at an altitude of 460 km was estimated. The surface material was presumed to be non-carbonaceous and inert. The determined number densities of the various gases relevant to the Space Station from both ambient and outgassing sources are presented. A model for the production of and emission from the infrared active molecules was constructed that considers two classes of production processes: (1) gas phase excitation of molecules in the near Station environment by collision with ambient flux; and (2) surface processes that lead to molecular excitation. A composite spectrum of all major emitting species shows that the observed irradiance is non-uniform over the 1 to 8 micron region. The comparison of predicted irradiance with the zodiacal background indicates that the Space Station infrared background from atmosphere-induced emissions may be a problem of consequence. Author

N88-25397*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

SPACE STATION PARTICULATE CONTAMINATION ENVIRONMENT

E. R. MILLER and K. S. CLIFTON *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 71-77 May 1988

Avail: NTIS HC A07/MF A01 CSCL 22B

The origin of particulate contamination on the Space Station will mostly be from pre-launch operations. The adherence and subsequent release of these particles during space flight are discussed. Particle size, release velocity, and release direction are important in determining particle behavior in the vicinity of the vehicle. The particulate environment at the principal science instrument locations is compared to the space shuttle bay environment. Recommendations for possibly decreasing the particulate contamination are presented. Author

N88-25398*# Physical Sciences, Inc., Andover, MA.

THE PARTICULATE ENVIRONMENT SURROUNDING THE SPACE STATION: ESTIMATES FROM THE PACS DATA

BYRON DAVID GREEN *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 79-90 May 1988

Avail: NTIS HC A07/MF A01 CSCL 22B

The objectives of the Particle Analysis Cameras for Shuttle (PACS) experiment (flown on STS-61C) are described and the experiment results are discussed in reference to the expected Space Station environment. Estimates of the sources of particulates surrounding the Space Station were made based on the existing orbital observations data base. Particulates surrounding the shuttle are mostly event related or from the residual release of mass (dust) brought to orbit from the ground. The particulates surrounding the Space Station are likely to arise from additional sources such as operations, docking, erosion, and abrasion. Thus, scaling of the existing data base to long-duration missions in low-Earth orbit requires analysis, modeling, and simulation testing. Author

N88-25399*# Science and Engineering Associates, Inc., Englewood, CO.

EFFECTS OF METEOROIDS AND SPACE DEBRIS ON THE PARTICULATE ENVIRONMENT FOR SPACE STATION

W. R. SEEBAUGH *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 91-99 May 1988

Avail: NTIS HC A07/MF A01 CSCL 22B

A large orbiting platform such as Space Station will be subjected to numerous impacts by meteoroids and space debris fragments. These hypervelocity impacts will produce clouds of ejected structural material in the vicinity of the Station. The development of a preliminary model for impact-generated ejecta production which combines the fluxes of meteoroids and space debris fragments with a description of the number of ejecta particles produced by hypervelocity impacts is reported. Modeling results give mean ejecta densities from 30 to 100 percent of the present particulate background limitation of 1 particle 5 microns and larger per orbit per 1 x 10(-5) sr field-of-view as seen by a 1-m-diameter aperture telescope in the 1990's time frame. Projected increases in the space debris flux raise this density to 300 percent of this limitation after 2010. The model is also applied to estimate the vulnerability of metallic claddings on composite structural members to penetration by hypervelocity projectiles, thereby exposing the substrate to atomic oxygen. The estimated annual number of penetrations is from 4 to 8 per square meter of cross-sectional area in the mid 1990's, increasing to more than 40 penetrations per square meter after 2010. Author

N88-25400*# Aerospace Corp., Los Angeles, CA. Chemistry and Physics Lab.

CONTAMINATION OF OPTICAL SURFACES

GRAHAM S. ARNOLD and DAVID F. HALL *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 101-108 May 1988

Avail: NTIS HC A07/MF A01 CSCL 22B

The effect of molecular contamination on Space Station optical surfaces is examined. In particular, contamination of solar voltaic power sources and optical solar reflectors for thermal control or solar dynamic power generation is addressed. The published Space Station requirements for molecular contamination accretion and for the monitoring of such accretion is discussed in the context of the historical performance of space systems. Specific reference is made to the results from the Spacecraft Charging at High Altitudes (SCATHA) ML12 experiment. Author

N88-25401*# Washington State Univ., Pullman. Dept. of Physics.

SURFACE INTERACTIONS RELEVANT TO SPACE STATION CONTAMINATION PROBLEMS

J. T. DICKINSON *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 109-121 May 1988
(Contract NSF DMR-86-01281)
Avail: NTIS HC A07/MF A01 CSCL 22B

The physical and chemical processes at solid surfaces which can contribute to Space Station contamination problems are reviewed. Suggested areas for experimental studies to provide data to improve contamination modeling efforts are presented. Author

N88-25402*# Physical Sciences, Inc., Andover, MA.

LABORATORY EXPERIMENTS OF RELEVANCE TO THE SPACE STATION ENVIRONMENT

G. E. CALEDONIA *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 123-130 May 1988
Avail: NTIS HC A07/MF A01 CSCL 22B

It has been found that the interaction between orbital vehicles and the ambient environment produces a contaminant cloud which can cause deletrious effects to spacecraft materials and equipment, create increased radiative backgrounds that would interfere with observational instrumentation, and enhance surface charging. A brief overview of the phenomena that produce the contaminant cloud is presented along with a review of physical data required to characterize it. Laboratory techniques which can be utilized to provide the required data are described. In particular, several oxygen beam apparati are discussed. Author

N88-25403*# Naval Research Lab., Washington, DC. Geophysical and Plasma Dynamics Branch.

CONTAMINATION OF THE SPACE STATION ENVIRONMENT BY VENTED CHEMICALS

PAUL A. BERNHARDT *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 131-140 May 1988
Avail: NTIS HC A07/MF A01 CSCL 22B

Gaseous materials vented from materials and life science experiments on the Space Station may have noticeable effects on the optical or plasma environment. The magnitude of the effects depends on: (1) rarefied gas dynamics; (2) photochemical reactions; and (3) airglow excitation mechanisms. In general, the effects from atomic species can be mitigated, but the disturbances resulting from venting of molecules like SF6, CO2 and C2H2 can be significant. The interaction of molecules with ambient plasma at orbital velocities should be studied with laboratory or space experiments. Author

N88-25474*# Minnesota Mining and Mfg. Co., Saint Paul.

DESIGN AND DEMONSTRATION OF A SYSTEM FOR THE DEPOSITION OF ATOMIC-OXYGEN DURABLE COATINGS FOR REFLECTIVE SOLAR DYNAMIC POWER SYSTEM CONCENTRATORS Final Contractor Report

DONALD J. MCCLURE Jul. 1988 68 p
(Contract NAS3-25075)
(NASA-CR-4158; E-4150; NAS 1.26:4158) Avail: NTIS HC A04/MF A01 CSCL 22B

A system for the vacuum deposition of atomic-oxygen durable coatings for reflective solar dynamic power systems (SDPS) concentrators was designed and demonstrated. The design issues pertinent to SDPS were developed by the Government Aerospace Systems Division of the Harris Corporation and are described in NASA-CR-179489. Both design and demonstration phases have been completed. At the time of this report the deposition system was ready for coating of facets for SDPS concentrators. The materials issue relevant to the coating work were not entirely resolved. These issues can only be resolved when substrates which are comparable to those which will be used in flight hardware are available. The substrates available during the contract period were deficient in the areas of surface roughness and contamination. These issues are discussed more thoroughly in the body of the report. Author

N88-27233# Martin Co., Denver, CO. Astronautics Group.

DAMPING CHARACTERISTICS OF METAL MATRIX COMPOSITES Quarterly Letter Progress Report No. 7, 11 Aug. - 9 Dec. 1987

MOHAN S. MISRA 9 Dec. 1987 7 p
(Contract N00014-85-C-0857)
(AD-A193144; MCR-85-721) Avail: NTIS HC A02/MF A01 CSCL 11D

Objectives of Present Research: Metal Matrix Composites (MMC) with enhanced material damping can be potential structural materials to improve significantly the stability, control and reliability of space structures. Objectives of this investigation are: - Identify the mechanisms and sources of damping in continuous fiber reinforced MMC (Gr/Al and Gr/Mg) using in situ characterization techniques. - Determine the role of microstructural parameters (fiber volume, fiber orientation, interfiber spacing, grain size, precipitate morphology) in damping. - Define the role of the fiber matrix interface in damping. - Develop high damping structural materials for space applications. GRA

N88-27341# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France). Div. Systemes Strategiques et Spatiaux.

REINFORCED PLASTICS: WINDING AND WEAVING TECHNOLOGIES FOR SPACE PRODUCTS

J. BOUVARD 1988 12 p In FRENCH
(REPT-881-430-103; ETN-88-92851) Avail: NTIS HC A03/MF A01

Multidirectional weaving and filament winding techniques are described and application examples to space structures are presented, including the Ariane 5 booster model, sandwich structures for several spacecraft, solar panel structures, helium containers, pipes, and inserts. It is shown that the space applications of these techniques are growing very fast due to definite weight saving advantages. ESA

N88-28754# Dynamics Technology, Inc., Torrance, CA.

LABORATORY FEASIBILITY STUDY OF A COMPOSITE EMBEDDED FIBER OPTIC SENSOR FOR MEASUREMENT OF STRUCTURAL VIBRATIONS Report, Oct. 1987 - Feb. 1988

C. M. DUBE, TOM D. WANG, ROBERT G. MELTON, DAVID W. JENSON, and MIKE KOHARCHIK (Pennsylvania State Univ., University Park.) Feb. 1988 47 p
(AD-A194270; DT-8723-01) Avail: NTIS HC A03/MF A01 CSCL 11D

The feasibility is assessed of using fiber optic strain sensors embedded in a composite material to measure the magnitude and frequency of structural vibrations for control of flexible elements. This study demonstrates the ability to embed fiber optic strain sensors in a composite material, determines the performance of these sensors, identifies active control system architectures that are matched to the fiber optic system measurands to damp vibrations of large space structures, and estimates the stability achievable by these methods. A detailed laboratory study was performed using a wide band closed-loop-fiber Mach-Zehnder interferometer to conduct transverse vibration measurements on sub-scale composite elements with embedded fiber sensors. The interferometer detects vibrations by measuring the strain transferred by the composite to the embedded optical fiber. The strain sensor demonstrated the ability to track the vibrations of a cantilever beam over a frequency bandwidth ranging from approximately 5

Hz to almost 1000 Hz. The sensor was unable to detect dc strains because of thermal drift and laser power fluctuations. These factors produced a drift in the dc signal level, which was indistinguishable from static strain measurements. Beyond 1000 Hz, the composite element was unable to follow the drive mechanism. The noise equivalent strain was epsilon is approximately 10 to the minus 10th power. GRA

N88-28833# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Materials and Processes Div.
THE TECHNICAL REPORTING AND APPROVAL PROCEDURE FOR MATERIALS AND PROCESSES
Oct. 1987 36 p
(ESA-PSS-01-700-ISSUE-1; ISSN-0379-4059; ETN-88-92781)
Avail: NTIS HC A03/MF A01

Details concerning the documentation requirements relevant to obtaining ESA approval for the use of materials and processes in the fabrication of space systems and associated equipment are provided. ESA

N88-28959*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ASSESSMENT OF THE EFFECTS OF SPACE DEBRIS AND METEOROIDS ENVIRONMENT ON THE SPACE STATION SOLAR ARRAY ASSEMBLY
HENRY K. NAHRA Sep. 1988 11 p Presented at the 20th Photovoltaic Specialists Conference, Las Vegas, Nev., 26-30 Sep. 1988; sponsored in part by IEEE
(NASA-TM-101315; E-4310; NAS 1.15:101315) Avail: NTIS HC A03/MF A01 CSCL 22B

The methodology used to assess the probability of no impact of space debris and meteoroids on a spacecraft structure is applied to the Space Station solar array assembly. Starting with the space debris and meteoroids flux models, the projected surface area of the solar cell string circuit of the solar array panel and the mast longeron, and the design lifetime, the possibility of no impact on the solar array mast and solar cell string circuits was determined as a function of particle size. The probability of no impact on the cell string circuits was used to derive the probability of no open circuit panel. The probability of meeting a certain power requirement at the end of the design lifetime was then calculated as a function of impacting particle size. Coupled with a penetration and damage models/correlations which relate the particle size to the penetration depth and damage, the results of this analysis can be used to determine the probability of meeting the lower power requirement given a degree of redundancy, and the probability of no impact on the solar array mast. Author

N88-28977# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
CONTRIBUTION TO THE STUDY OF MATERIALS BEHAVIOR IN SPACE ENVIRONMENT
P. PLOTARD and F. ALBUGUES 1988 9 p
(SNIAS-881-430-104; ETN-88-92852) Avail: NTIS HC A02/MF A01

Facilities to study dimensional stability and for nondestructive in situ analysis of spacecraft materials and components are described. The simulation takes into account solar UV, vacuum, temperature, thermal cycle, and particle effects, with computed dose evaluation corresponding to selected orbits. Results for kevlar and carbon with epoxy resin matrix composites are presented. ESA

N88-28978# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
VERY HIGH TEMPERATURE MATERIALS FOR MECHANICAL APPLICATION
V. L. MAGRET and A. HORBONNEAU 1988 5 p
(SNIAS-881-430-106; ETN-88-92854) Avail: NTIS HC A02/MF A01

Ceramic composite materials which demonstrate temperature resistance up to 1400 C, and oxidation resistant carbon-carbon with coating adapted to service temperature were developed for space use. Base on experience in weaving and densification, demonstration parts were manufactured. ESA

N88-29190# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Materials and Processes Div.
MATERIAL AND PROCESS SELECTION AND QUALITY CONTROL FOR ESA SPACE SYSTEMS AND ASSOCIATED EQUIPMENT
Oct. 1987 26 p
(ESA-PSS-01-70-ISSUE-3; ISSN-0379-4059; ETN-88-92913)
Avail: NTIS HC A03/MF A01

The requirements for a material and process selection and control program for space systems and associated equipment in which the use of controlled materials and processes is mandatory are established. ESA

N88-30012# Universidad Autonoma de Madrid, Cantoblanco (Spain). Dept. of Applied Physics.
STUDY OF SECONDARY EMISSION PROPERTIES OF MATERIALS USED FOR HIGH POWER RF COMPONENTS IN SPACE Final Report
L. GALAN, C. MORANTI, F. RUEDA, and J. M. SANZ Paris, France ESA 1988 86 p
(Contract ESTEC-6577/85-NL-PB)
(ESA-CR(P)-2587; ETN-88-93031) Avail: NTIS HC A05/MF A01

Secondary electron emission (SEE) properties of materials used for high power waveguide components in space, particularly on surfaces for space hardware were studied, including Alodine surfaces before and after power conditioning. Surface treatments to aid multipactor suppression for these materials, including methods for surface protection and handling, were examined. If only true SEE is considered, Alodine coatings have better characteristics than TiN, TiC, Cr2O3, and C. The rugosity of Alodine may explain its good properties. No clear correlation between SEE characteristic values and multipactor threshold power is found; smaller SEE is not determinant for obtaining higher multipactor threshold power. ESA

08

ASSEMBLY CONCEPTS

Includes automated manipulator techniques, EVA, robot assembly, teleoperators, and equipment installation.

A88-33433
LARGE SPACE SYSTEM ASSEMBLY OPTIONS
MICHAEL K. BAILY (Martin Marietta Corp., Denver, CO) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 61-74.

Methods and techniques used to display various large space structure assembly sequence alternatives are discussed. The launch vehicle performance and requirements definition of the major elements to be assembled and delivered and assembled in orbit are considered along with logistics and module outfitting requirements. A Space Station manifest for each mission, the Shuttle performance parameters, and the dynamic requirements for Station weight, altitude, and system are considered. C.D.

A88-33440
ON-ORBIT ASSEMBLY, INTEGRATION, AND TEST OF LARGE SPACECRAFT - A NEW TECHNIQUE
WALTON CLARK (TRW, Inc., Redondo Beach, CA) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16,

1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 121-126. refs

A new and unique on-orbit assembly, interaction, and test technique designed to decrease the cost of any space-vehicle program without increasing the risk of failure on-orbit is presented. In the new approach, the vehicle is completely assembled on-orbit prior to the activation of any subsystems. Services essential during buildup are provided by a separate autonomous support vehicle. The new technique eliminates the need for multiple configurations of each subsystem and simplifies the on-orbit deployment activity. C.D.

A88-33789*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

TEST PROGRAM TO EVALUATE ESD SUSCEPTIBILITY OF EVA SUIT MATERIAL

PHILIP LEUNG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Aerospace Testing Seminar, 10th, Los Angeles, CA, Mar. 10-12, 1987, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1987, p. 105-110. refs
(Contract NAS7-918)

This paper presents the details of a test program for the evaluation of the electrostatic discharge susceptibility of extravehicular activity equipment in polar orbits. In this program, laboratory simulation tests were performed to obtain the charging and ESD characteristics of the spacesuit material. The results from the simulation tests were used to generate the parameters for a system level ESD test for the existing EVA equipment. These test parameters were also used as a guide for the selection of the test apparatus. Author

A88-35111

CONCEPTS AND ISSUES FOR A SPACE TELEROBOT

JIM CHAPEL (Martin Marietta Corp., Denver, CO) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 971-984. refs
(AAS PAPER 86-302)

The requirement for a dexterous space teleoperator for Space Station activities are presently addressed by a dextrerous space telerobotic servicer concept which will be equivalent in capabilities to an astronaut on EVA duties. The potential benefits derivable from the incorporation of force feedback, compliant teleoperation, predictive displays, computer vision, and supervisory control are discussed. Attention is drawn to the substantial amount of off-the-shelf hardware that is directly applicable to the present telerobotic servicer concept. O.C.

A88-35452

HANDGRIP STRENGTH WITH THE BARE HAND AND IN THE NASA SPACESUIT GLOVE

J. RICHARD ROESCH (Human Factors Applications, Inc., Panama City, FL) IN: Human Factors Society, Annual Meeting, 31st, New York, NY, Oct. 19-23, 1987, Proceedings. Volume 2. Santa Monica, CA, Human Factors Society, 1987, p. 786-790. refs

This study examined handgrip strength with the bare and spacesuit-gloved hand, in three hand- and two elbow positions. Sixteen subjects from the suited-subject pool at NASA/Johnson Space Center gripped a hand dynamometer encased in a vacuum chamber designed to simulate the pressure differential of the spacesuit in space. With the bare hand (at one atmosphere), there was an effect for hand position and a hand-position x elbow-position interaction. With the spacesuit-gloved hand, there was only an effect for hand position. Two different pressure differentials were used; the glove at 0.5 psid was responsible for a 35 percent grip decrement (when compared to bare handgrip); the glove at 4.3 psid (normal operating pressure) was responsible for a 42 percent grip decrement. Bare and gloved-handgrips were positively correlated with hand size, body weight, height, and forearm circumference. Post hoc, subjects were grouped by hand size; the four subjects in the XL hand-size group lost an average of 17 percent in grip in the glove at 4.3 psid (when compared to the glove at 0.5 psid); the L group lost 12 percent; the M group lost 9 percent; and the S hand-size group lost less than 1 percent. Author

A88-35453* Grumman Aerospace Corp., Bethpage, NY.

TELEROBOTIC CONTROL OF A DEXTROUS MANIPULATOR USING MASTER AND SIX-DOF HAND-CONTROLLERS FOR SPACE ASSEMBLY AND SERVICING TASKS

JOHN M. O'HARA (Grumman Corp., Grumman Space Systems Div., Bethpage, New York) IN: Human Factors Society, Annual Meeting, 31st, New York, NY, Oct. 19-23, 1987, Proceedings. Volume 2. Santa Monica, CA, Human Factors Society, 1987, p. 791-795. refs
(Contract NAS9-17229)

Two studies were conducted evaluating methods of controlling a telerobot; bilateral force reflecting master controllers and proportional rate six degrees of freedom (DOF) hand controllers. The first study compared the controllers on performance of single manipulator arm tasks, a peg-in-the-hole task, and simulated satellite orbital replacement unit changeout. The second study, a Space Station truss assembly task, required simultaneous operation of both manipulator arms (all 12 DOFs) and complex multiaxis slave arm movements. Task times were significantly longer and fewer errors were committed with the hand controllers. The hand controllers were also rated significantly higher in cognitive and manual control workload on the two-arm task. The master controllers were rated significantly higher in physical workload. There were no significant differences in ratings of manipulator control quality. Author

A88-35455

CREW-INDUCED LOAD MEASUREMENT FOR SPACE OPERATIONS

RUTHAN LEWIS (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IN: Human Factors Society, Annual Meeting, 31st, New York, NY, Oct. 19-23, 1987, Proceedings. Volume 2. Santa Monica, CA, Human Factors Society, 1987, p. 800-802.

A method has been developed to simulate and measure crew-induced and reactive loads for a variety of intravehicular and extravehicular tasks. The method employs the use of a dynamometer attached to an adjustable support, and a three-axis force/torque platform. Translational and rotational hand/arm forces and torques, and foot reaction forces and torques may be measured simultaneously. The apparatus has been designed for on-orbit and ground-based usage. Beyond explanation of the instrumentation, the presentation will address data on forces effected by crew members, and the applications, implications, and integration of the information with regards to planning space operations and design of crew-interfaced items. Author

A88-35457* Lockheed Engineering and Management Services Co., Inc., Houston, TX.

HUMAN-TELEROBOT INTERACTIONS - INFORMATION, CONTROL, AND MENTAL MODELS

RANDY L. SMITH and DOUGLAS J. GILLAN (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IN: Human Factors Society, Annual Meeting, 31st, New York, NY, Oct. 19-23, 1987, Proceedings. Volume 2. Santa Monica, CA, Human Factors Society, 1987, p. 806-810. refs
(Contract NAS9-17900)

A part of the NASA's Space Station will be a teleoperated robot (telerobot) with arms for grasping and manipulation, feet for holding onto objects, and television cameras for visual feedback. The objective of the work described in this paper is to develop the requirements and specifications for the user-telerobot interface and to determine through research and testing that the interface results in efficient system operation. The focus of the development of the user-telerobot interface is on the information required by the user, the user inputs, and the design of the control workstation. Closely related to both the information required by the user and the user's control of the telerobot is the user's mental model of the relationship between the control inputs and the telerobot's actions. Author

A88-35462

A METHOD FOR MEASURING THE EFFECT OF GRIP SURFACE ON TORQUE PRODUCTION DURING HAND/ARM ROTATION

RUTHAN LEWIS (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IN: Human Factors Society, Annual Meeting, 31st, New York, NY, Oct. 19-23, 1987, Proceedings. Volume 2. Santa Monica, CA, Human Factors Society, 1987, p. 898-900.

During EVA operations, where time is extremely limited, a grip interface that would cause regripping of a surface or repositioning of the hand to assume a more effective or more comfortable grip must be avoided. This paper presents a method for measuring the effect of grip surface on torque production during rotation by the space-gloved hand during a simulated on-orbit construction operation. An isokinetic dynamometer was used as the measuring device to distinguish human interface differences between various connector surface types; the device was used to test single-joint-effected motions, registering torque and the position of the torque within the range of motion at the joint as a function of applied load. It is shown that this method can be used to simulate the complex resultant of mutiple-joint motion. Controls can be instituted according to the application, so that comparisons of static and dynamic measures can be made between specified conditions. I.S.

A88-35942#

DESIGNING SPACE STATION STRUCTURE FOR ASSEMBLY

F. DAVID RIEL (McDonnell Douglas Astronautics Co., Space Station Div., Huntington Beach, CA) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 7 p.
(AIAA PAPER 88-2453)

The principal factors influencing the design of the Space Station, which will be approximately 650 feet wide by 350 feet tall when fully deployed, are examined. In particular, the design of the primary truss structure to be assembled in space is described, and it is shown how the design decisions have been influenced by assembly considerations. The decisions discussed include those related to incremental growth, maintenance, Orbiter capability, EVA capability, and test and verification methods. V.L.

A88-42328

ROBOT PATH PLANNING IN SPACE

A. F. BRINDLE, W. KOHN, G. M. LOBDELL, and J. H. ALBERT (Boeing Co., Seattle, WA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 26-34. refs

This project is investigating autonomous path planning for vehicles such as satelllite services operating on orbit. In the spacecraft domain, the problem of planning for obstacle avoidance is compounded by several interesting features, most notably the need to avoid plume impingement. The plume from the thrusters of a robotic vehicle may impose particle contamination or orbit altering forces upon other bodies as the vehicle navigates. The system under development is a hierarchical planner with modules for: (1) waypoint generation based on simple constraint models and, heuristics. (2) waypoint realignment or smoothing, (3) generation of a pipe representing feasible trajectories from the robot to the next waypoint, and (4) trajectory planning. The planner is placed within a system which simulates the sensing and control for a vehicle similar to NASA's Manned Maneuvering Unit. This paper discusses the architecture of the planner and the coinstraints which the modules must address. Author

A88-42642* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

ROBOTIC VISION/SENSING FOR SPACE APPLICATIONS

KUMAR KRISHEN, OLIN GRAHAM (NASA, Johnson Space Center Houston, TX), and RUI J. P. DE FIGUEIREDO (Rice University, Houston, TX) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 1. Washington, DC, IEEE Computer Society Press, 1987, p. 138-150. refs
(Contract NAS9-17145; N00014-85-K-0152; NSF DCR-83-18514)

A review is presented of efforts currently in progress at the NASA/Johnson Space Center and Rice University, the accomplishments to date, and some of the anticipated future developments. Both systems and algorithms are discussed. The evolution of future vision/sensing is projected to included the fusion of multisensors ranging from microwave to optical with multimode capability to include position, attitude, recognition, and motion parameters. The algorithms for information extraction are expected to incorporate aspects of intelligence and knowledge for the interpolation and extrapolation of the needed data. The key features of the overall system design will be small size and weight, fast signal processing, robust algorithms, and accurate parameter determination. These aspects of vision/sensing are also discussed. I.E.

A88-42657* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SENSING AND PERCEPTION RESEARCH FOR SPACE TELEROBOTICS AT JPL

DONALD B. GENNERY, TODD LITWIN, BRIAN WILCOX, and BRUCE BON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 1. Washington, DC, IEEE Computer Society Press, 1987, p. 311-317. refs

PIFLEX is a pipelined-image processor that can perform elaborate computations whose exact nature is not fixed in the hardware, and that can handle multiple images. A wire-wrapped prototype PIFEX module has been produced and debugged, using a version of the convolver composed of three custom VLSI chips (plus the line buffers). A printed circuit layout is being designed for use with a single-chip convolver, leading to production of a PIFEX with about 120 modules. A high-level language for programming PIFEX has been designed, and a compiler will be written for it. The camera calibration software has been completed and tested. Two more terms in the camera model, for lens distortion, probably will be added later. The acquisition and tracking system has been designed and most of it has been coded in Pascal for the MicroVAX-II. The feature tracker, motion stereo module and stereo matcher have executed successfully. The model matcher is still under development, and coding has begun on the tracking initializer. The object tracker was running on a different computer from the VAX, and preliminary runs on real images have been performed there. Once all modules are working, optimization and integration will begin. Finally, when a sufficiently large PIFEX is available, appropriate parts of acquisition and tracking, including much of the feature tracker, will be programmed into PIFEX, thus increasing the speed and robustness of the system. I.E.

A88-42667

THE SPACE AND TELEROBOTIC CONCEPTS OF DFVLR ROTEX

G. HIRZINGER (DFVLR, Institut fuer Dynamik der Flugsysteme, Wessling, Federal Republic of Germany) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 1. Washington, DC, IEEE Computer Society Press, 1987, p. 443-449. refs

Concepts are outlined for a robot technology experiment ROTEX the author has proposed to fly with the next Germany spacelab, mission D2 (originally planned for 1988, but delayed for at least two years). It provides a small, six-axis robot inside a space-lab rack, equipped with a multisensory gripper (force/torque, an array of range finders, stereo optical fibers). The robot is supposed to handle a biological experiment, to perform several assembly and servicing tasks, and to grasp floating objects. The authors focus on the man-machine and supervisory control concepts for teleoperation from the spacecraft and from ground and especially explains the predictive estimation schemes for an extensive use of delay-compensating three-dimensional computer graphics. I.E.

A88-42668*# Oak Ridge National Lab., TN.
TRACTION-DRIVE TELEROBOT FOR SPACE MANIPULATION
J. N. HERNDON, W. R. HAMEL, and D. P. KUBAN (Oak Ridge National Laboratory, TN) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 1. Washington, DC, IEEE Computer Society Press, 1987, p. 450-455. NASA-supported research. Previously announced in STAR as N87-22233. refs
(Contract DE-AC05-84OR-21400)

The National Aeronautics and Space Administration (NASA) Space Station Program marks the begining of a new era in space utilization and habitation. Extensive use of remote manipulation and robotics to reduce astronaut extra-vehicular activity is expected. Emphasis on teleoperator technology in early Space Station phases, followed by growth of autonomous robotics capabilities, is planned. A new telerobot concept has been developed at Oak Ridge National Laboratory (ORNL) under NASA Langley Research Center sponsorship, to address the technical needs of both teleoperations and telerobotics for these future NASA programs. The concept is based on traction drives, redundant kinematics, modular construction, and a state-of-the-art distributed, hierarchical control system. Author

A88-42677* Massachusetts Inst. of Tech., Cambridge.
ON THE DYNAMICS OF MANIPULATORS IN SPACE USING THE VIRTUAL MANIPULATOR APPROACH
Z. VAFA and S. DUBOWSKY (MIT, Cambridge, MA) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 1. Washington, DC, IEEE Computer Society Press, 1987, p. 579-585. refs
(Contract NAG1-489)

A virtual manipulator (VM) concept has been developed recently for the modeling of manipulators working in space. The authors show that the VM facilitates planning and control of the motions of manipulators mounted on spacecraft, minimizing the degrading consequences of manipulator/vehicle dynamic interactions. I.E.

A88-42903*# Booz-Allen and Hamilton, Inc., Bethesda, MD.
OPTIMAL USE OF HUMAN AND MACHINE RESOURCES FOR SPACE STATION ASSEMBLY OPERATIONS
JOSEPH C. PARRISH (Booz-Allen and Hamilton, Inc., Bethesda, MD) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 12 p. refs
(Contract NASW-4300)
(AIAA PAPER 88-3498)

This paper investigates the issues involved in determining the best mix of human and machine resources for assembly of the Space Station. It presents the current Station assembly sequence, along with descriptions of the available assembly resources. A number of methodologies for optimizing the human/machine tradeoff problem have been developed, but the Space Station assembly offers some unique issues that have not yet been addressed. These include a strong constraint on available EVA time for early flights and a phased deployment of assembly resources over time. A methodology for incorporating the previously developed decision methods to the special case of the Space Station is presented. This methodology emphasizes an application of multiple qualitative and quantitative techniques, including simulation and decision analysis, for producing an objective, robust solution to the tradeoff problem. Author

A88-43976#
COMPUTATIONAL TECHNIQUES FOR THE SELF ASSEMBLY OF LARGE SPACE STRUCTURES
ALAN H. BARR, BRIAN VON HERZEN, RONEN BARZEL, and JOHN SNYDER (California Institute of Technology, Pasadena) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 275-282. refs

We present a new computational technique, dynamic constraints, which is potentially applicable to the computer aided design, modeling, and control of the self assembly of large space structures. The technique models the dynamic behavior of mechanical elements, subject to geometric constraints on their final configuration. The constraints are met by applying external forces to the elements of the structure during assembly. The techniques are envisioned as being useful for calculating the strength of rocket impulses for automated docking maneuvers, for smoothly eliminating residual velocities and angular velocities associated with self-assembly, and for other applications where we wish to create homeostatic spatial relationships between space platforms and other structures. The technique will also be useful as a computer aided design tool for these applications. Author

A88-44526*# SDRC, Inc., San Diego, CA.
AN ASSESSMENT OF NOMINAL AND CONTINGENCY ALTITUDE REBOOST SCENARIOS DURING SPACE STATION ASSEMBLY
VINCENT J. BILARDO, JR., JOHN HUDIBURG (NASA, Space Station Program Office, Reston, VA), and LEWIS COLLINS (SDRC, Inc., San Diego, CA) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 13 p. refs
(AIAA PAPER 88-3501)

The results of an analysis of several reboost scenarios for nominal and contingency SS operations during the Phase I assembly sequence are presented. Space Station program requirements on assembly and operational altitudes are outlined, and essential features of the SS reaction control system are described. A nominal reboost strategy designed to meet the current program requirements is presented. In addition, reboost strategies are developed for several contingency scenarios, including one missed STS mission, and an extended STS outage. It is shown that the time-averaged propellant 'cost' of maintaining altitude is greatest for equivalent continuous-thrusting altitude maintenance; it decreases with increasing reboost/rendezvous time interval to an asymptotic minimum value. K.K.

A88-50202#
THE KINETICS AND WORKSPACE OF A ROBOT MOUNTED ON A SATELLITE THAT IS FREE TO ROTATE AND TRANSLATE
RICHARD W. LONGMAN (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 374-381. refs
(AIAA PAPER 88-4097)

Satellite mounted robots are considered that manipulate loads whose mass is not negligible compared to the satellite mass. By contrast to previous works on this subject, the satellite is considered free to not only translate, but to rotate as well, in reaction to robot motions. Three basic topics in robotics, the forward kinematics, the inverse kinematics, and the robot workspace, are generalized here for the problem at hand. The generalized versions of the kinematics problems are found to have become dynamics problems instead - their solutions are functions of the whole history of robot motion rather than the final joint angles alone. It is demonstrated that any desired satellite orientation can be obtained for any final robot joint angles. The robot workspace is generated, and found to be a perfect sphere whose radius is a function of the load mass. The workspace is compared to that of a robot on an attitude fixed satellite, and an inertially mounted robot, and found to be larger in many cases. Author

A88-50862
LARGE TRUSS STRUCTURES
M. SIERRA (Sener-Ingenieria y Sistemas, S.A., Las Arenas, Spain) and M. FUENTES (Sener-Ingenieria y Sistemas, S.A., Madrid,

Spain) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1091-1097.

The possible use of deployable structures that reach their final configuration in orbit is discussed. The existing concepts of deployable structures are classified into groups. The dynamic behavior of these structures in the fully stowed condition, during the intermediate deployment sequence, and in the fully deployed condition are examined. Four specific deployable trusses from a study made by the ESA are presented and analyzed. R.B.

A88-50998

HUMAN FACTORS ANALYSIS OF EXTRAVEHICULAR SERVICING OF PAYLOADS WITHIN THE SPACE STATION SERVICING FACILITY

RAY A. REAUX, REBECCA L. SHANNON, and SYLVIA B. SHEPPARD (Computer Technology Associates, Inc., McLean, VA) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 784-788. refs

A series of studies on extravehicular (EV) servicing of payloads was performed for the space station on-orbit assembly, maintenance, and servicing project at Goddard Space Flight Center (GSFC). The studies covered three types of servicing that could be performed in the space station servicing facility: change-out of orbital replacement units (ORUs), on-orbit assembly, and fluid replenishment. Servicing activities were decomposed into functions, subfunctions, and tasks. The tasks were allocated to EV, intravehicular (IV), and ground personnel. The temporal flow of the tasks was described using the computer-human operational requirements analysis system (CHORAS), an inhouse graphic tool that models the role of the human operator in a complex system. Once tasks were defined, detailed analyses were performed to identify the cognitive, sensory, and motor skills, information (data flows), and equipment needed to perform each task. The results of the studies include: a detailed operations concept for space station-based payload servicing, work performance issues, and design recommendations for procedures, equipment, and performance aids. In particular, recommendations for the design of the space station servicing facility and related servicing equipment were specified. I.E.

A88-52323

TELEROBOTIC SPACE STATION APPLICATIONS

SCOTT A. HOFACKER (United Technologies Corp., Huntsville, AL), BERNARD J. SCHROER, and ARTHUR HERKERT (Alabama, University, Huntsville) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 3-9 to 3-14. refs

Issues related to space telerobotics and research concerning the Space Station applications of telerobotics are reviewed. The number of camera views needed for a telerobotic task, black and white vs. color view, the camera position for telerobotic tasks, lighting intensity and position, feedback delays, predictive displays, the types of end effectors needed for space tasks, the number of robot arms necessary, reach considerations, and design for space automation are discussed. The development and use of a space telerobotics laboratory are examined. Also, telerobotics space requirements and applications are listed. R.B.

A88-52326

AUTOMATION AND ROBOTICS FOR EXPERIMENT OPERATIONS IN AN ENHANCED MAN TENDED FREE FLYER (EMTFF)

EIKE SCHMIDT (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 3-38 to 3-46.

As a baseline for investigations into automation and robotics for microgravity experiment operations an enhanced version of the Columbus Man Tended Free Flyer (MTFF) is used. Four relevant experiments are selected as a basis for detailed analysis to derive typical classes of experiment tasks which have crucial importance for the identification of automation and robotics concepts. The description of the Enhanced MTFF (EMTFF), a definition of a reference payload, and the derivation of a preliminary concept for EMTFF automation is presented in this paper as results of an appropriate study funded by ESA/ESTEC. Author

A88-52328* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.

ROBOTIC APPLICATIONS AT KENNEDY SPACE CENTER

DAN WEGERIF, MIKE SKLAR, and RON DESPAIN (NASA, Kennedy Space Center; McDonnell Douglas Astronautics Co., Cocoa Beach, FL) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 3-66 to 3-75. refs

McDonnell Douglas performed a study (1987) to find effective application of robots and their associated technology at the Kennedy Space Center (KSC). Specifically, this study was directed toward the newly planned Space Station Processing Facility (SSPF). Because the Operations and Checkout (O and C) building has a similar charter to that of the SSPF, the O and C was carefully checked for potential robotic applications. Eleven applications were discovered and a trade study developed to rate these applications. Twenty more applications external to the SSPF were found during additional studies. These robotic tasks fall into three major categories including: teleoperated robots for hazardous tasks, mobile robots for repetitive tasks and feedback compensated robots for refurbishment and inspection tasks. This paper highlights some of the requirements for these tasks and others external to the SSPF. Additionally, the resources available at KSC are discussed. Author

A88-52329* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AUTOMATION AND ROBOTICS FOR THE SPACE STATION - THE INFLUENCE OF THE ADVANCED TECHNOLOGY ADVISORY COMMITTEE

ROBERT R. NUNAMAKER and KELLI F. WILLSHIRE (NASA, Langley Research Center, Hampton, VA) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 3-76 to 3-79.

The reports of a committee established by Congress to identify specific systems of the Space Station which would advance automation and robotics technologies are reviewed. The history of the committee, its relation to NASA, and the reports which it has released are discussed. The committee's reports recommend the widespread use of automation and robotics for the Space Station, a program for technology development and transfer between industries and research and development communities, and the planned use of robots to service and repair satellites and their payloads which are accessible from the Space Station. R.B.

A88-52330* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.

SYSTEMS INTEGRATION FOR THE KENNEDY SPACE CENTER (KSC) ROBOTICS APPLICATIONS DEVELOPMENT LABORATORY (RADL)

V. LEON DAVIS and ROSS NORDEEN (NASA, Kennedy Space Center, Cocoa Beach, FL) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 3-80 to 3-88.

A laboratory for developing robotics technology for hazardous and repetitive Shuttle and payload processing activities is discussed. An overview of the computer hardware and software responsible for integrating the laboratory systems is given. The center's anthropomorphic robot is placed on a track allowing it to be moved to different stations. Various aspects of the laboratory equipment are described, including industrial robot arm control, smart systems integration, the supervisory computer, programmable process controller, real-time tracking controller, image processing hardware, and control display graphics. Topics of research include automated loading and unloading of hypergolics for space vehicles and payloads; the use of mobile robotics for security, fire fighting, and hazardous spill operations; nondestructive testing for SRB joint and seal verification; Shuttle Orbiter radiator damage inspection; and Orbiter contour measurements. The possibility of expanding the laboratory in the future is examined. R.B.

A88-53665*# Massachusetts Inst. of Tech., Cambridge.
A DESIGN METHODOLOGY FOR NEUTRAL BUOYANCY SIMULATION OF SPACE OPERATIONS
DAVID L. AKIN (MIT, Cambridge, MA) IN: AIAA, Flight Simulation Technologies Conference, Atlanta, GA, Sept. 7-9, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 313-318. refs
(Contract NAGW-21)
(AIAA PAPER 88-4628)

Neutral buoyancy has often been used in the past for EVA development activities, but little has been done to provide an analytical understanding of the environment and its correlation with space. This paper covers a set of related research topics at the MIT Space Systems Laboratory, dealing with the modeling of the space and underwater environments, validation of the models through testing in neutral buoyancy, parabolic flight, and space flight experiments, and applications of the models to gain a better design methodology for creating meaningful neutral buoyancy simulations. Examples covered include simulation validation criteria for human body dynamics, and for applied torques in a beam rotation task, which is the pacing crew operation for EVA structural assembly. Extensions of the dynamics models are presented for powered vehicles in the underwater environment, and examples given from the MIT Space Telerobotics Research Program, including the Beam Assembly Teleoperator and the Multimode Proximity Operations Device. Future expansions of the modeling theory are also presented, leading to remote vehicles which behave in neutral buoyancy exactly as the modeled system would in space. Author

A88-55320#
TELEPRESENCE FOR SPACE APPLICATIONS
G. M. MCKINNON and M. L. KING (CAE Electronics, Ltd., Montreal, Canada) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 5 p. refs
(IAF PAPER 88-018)

In future space applications, the remote operation of manipulators for maintenance and assembly tasks will take on much greater importance. This paper reviews some of the principal concerns in the field of teleoperation, with particular reference to applications in space. A generalized approach to the control of telemanipulators, and other remote devices is presented. In particular, the remote control of manipulators and the requirements for associated displays are discussed. Author

A88-55324#
SPACE INSPECTION DEVICE FOR EXTRAVEHICULAR REPAIRS - SPIDER SYSTEM
SIMONETTA DI PIPPO and GIOVANNI SYLOS LABINI (CNR, Rome, Italy) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 6 p.
(IAF PAPER 88-029)

The main characteristics of the proposed space inspection device for extravehicular repairs (SPIDER) which is being devloped for use in the Space Station environment is discussed. The SPIDER system is an autonomous integrated space robot which uses AI tools and techniques for operational control. The SPIDER is expected to be 150 X 90 cm and weigh about 400 kg. The first phase of the SPIDER program, the development of a teleoperated vehicle for visual inspection is examined in detail. Other phases of the program include autonomous navigation, docking, and repairing. R.B.

A88-55436#
EVA SPACE SUITS - SAFETY PROBLEMS
G. I. SEVERIN, I. P. ABRAMOV, and V. I. SVERTSHEK (AN SSSR, Sovet Interkosmos, Moscow, USSR) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p.
(IAF PAPER 88-515)

Design features of semirigid space suits and portable life support systems for the Salyut and Mir space stations are reviewed. Ways of providing system reliability in these suits are highlighted. It is shown that the solution to the problem of EVA safety is found in the selection of the proper design concepts and arrangements, adequate operating modes, proven manufacturing techniques, and comprehensive development test programs. C.D.

N88-20352*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE SPACE STATION ASSEMBLY PHASE: FLIGHT TELEROBOTIC SERVICER FEASIBILITY. VOLUME 2: METHODOLOGY AND CASE STUDY
JEFFREY H. SMITH, MAX A. GYAMFI, KENT VOLKMER, and WAYNE F. ZIMMERMAN Sep. 1987 161 p
(Contract NAS7-918)
(NASA-CR-182690; JPL-PUBL-87-42-VOL-2; NAS 1.26:182690)
Avail: NTIS HC A08/MF A01 CSCL 22B

A methodology is described for examining the feasibility of a Flight Telerobotic Servicer (FTS) using two assembly scenarios, defined at the EVA task level, for the 30 shuttle flights (beginning with MB-1) over a four-year period. Performing all EVA tasks by crew only is compared to a scenario in which crew EVA is augmented by FTS. A reference FTS concept is used as a technology baseline and life-cycle cost analysis is performed to highlight cost tradeoffs The methodology, procedure, and data used to complete the analysis are documented in detail. Author

N88-20646*# Massachusetts Inst. of Tech., Cambridge. Dept. of Mechanical Engineering.
THE DYNAMIC CONTROL OF ROBOTIC MANIPULATORS IN SPACE Semiannual Report, 31 Jul. 1987 - 31 Jan. 1988
S. DUBOWSKY 29 Apr. 1988 30 p
(Contract NAG1-801)
(NASA-CR-182710; NAS 1.26:182710; SAR-1) Avail: NTIS HC A03/MF A01 CSCL 13I

Described briefly is the work done during the first half year of a three-year study on dynamic control of robotic manipulators in space. The research focused on issues for advanced control of space manipulators including practical issues and new applications for the Virtual Manipulator. In addition, the development of simulations and graphics software for space manipulators, begun during the first NASA proposal in the area, has continued. The fabrication of the Vehicle Emulator System (VES) is completed and control algorithms are in process of development. Author

N88-21232# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).
A JOINT ACTUATOR DESIGN FOR A ROBOTIC MANIPULATOR
K. PRIESETT *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 311-316 Dec. 1987
Avail: NTIS HC A14/MF A01

A rotary actuator design for space robotic manipulator applications was established. Major characteristics are high torque capability, high stiffness, very low backlash, backdriveability, and high resolution position measurement. The unit is very compact and includes a cyclo drive as the major gear system. However, due to the modular concept, a different gear system could be implemented with only minor changes in the gearbox module. The results of the main trade-offs performed on the gear system are summarized. ESA

N88-21474*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MOTION SYNCHRONIZATION OF A MECHANISM TO DEPLOY AND RESTOW A TRUSS BEAM
M. LUCY *In its* The 22nd Aerospace Mechanisms Symposium, p

67-85 May 1988
Avail: NTIS HC A18/MF A01 CSCL 13E

The functions of the Control of Flexible Structures I (COFS I) deployer and retractor assembly (DRA) are primarily to deploy and retract the Mast I beam, and secondarily to latch, unlatch, and restow the DRA mechanism. The problems associated with the diagonal folding mechanism that retracts the beam is presented, the synchronization requirements critical to the process of restowing the beam is discussed, and a proposed solution to the problem of synchronization between the mechanical systems is presented. In addition, a detailed description is presented of the design and functioning of the DRA. Author

N88-21489*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OPERATIONAL EXPERIENCE AND DESIGN RECOMMENDATIONS FOR TELEOPERATED FLIGHT HARDWARE
T. W. BURGESS, D. P. KUBAN (Oak Ridge National Lab., Tenn.), W. W. HANKINS, and R. W. MIXON *In its* The 22nd Aerospace Mechanisms Symposium p 287-305 May 1988
(Contract DE-AC05-84OR-21400)
Avail: NTIS HC A18/MF A01 CSCL 13I

Teleoperation (remote manipulation) will someday supplement/minimize astronaut extravehicular activity in space to perform such tasks as satellite servicing and repair, and space station construction and servicing. This technology is being investigated by NASA with teleoperation of two space-related tasks having been demonstrated at the Oak Ridge National Lab. The teleoperator experiments are discussed and the results of these experiments are summarized. The related equipment design recommendations are also presented. In addition, a general discussion of equipment design for teleoperation is also presented. Author

N88-22540*# Stanford Univ., CA. Center for Design Research.
DESIGN, DEVELOPMENT AND EVALUATION OF STANFORD/AMES EVA PREHENSORS Final Report
LARRY J. LEIFER, J. ALDRICH, M. LEBLANC, E. SABELMAN, and D. SCHWANDT May 1988 10 p
(Contract NCC2-295)
(NASA-CR-182688; NAS 1.26:182688) Avail: NTIS HC A02/MF A01 CSCL 05H

Space Station operations and maintenance are expected to make unprecedented demands on astronaut EVA. With Space Station expected to operate with an 8 to 10 psi atmosphere (4 psi for Shuttle operations), the effectivness of pressurized gloves is called into doubt at the same time that EVA activity levels are to be increased. To address the need for more frequent and complex EVA missions and also to extend the dexterity, duration, and safety of EVA astronauts, NASA Ames and Stanford University have an ongoing cooperative agreement to explore and compare alternatives. This is the final Stanford/Ames report on manually powered Prehensors, each of which consists of a shroud forming a pressure enclosure around the astronaut's hand, and a linkage system to transfer the motions and forces of the hand to mechanical digits attached to the shroud. All prehensors are intended for attachment to a standard wrist coupling, as found on the AX-5 hard suit prototype, so that realistic tests can be performed under normal and reduced gravity as simulated by water flotation. Author

N88-23237*# Army Aviation Systems Command, Cleveland, OH. Structural Dynamics Branch.
MICROGRAVITY MECHANISMS AND ROBOTICS PROGRAM
DOUGLAS A. ROHN *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 143-155 May 1988
Avail: NTIS HC A20/MF A01 CSCL 13I

The primary goal of this program is to produce the motion control tools necessary to enhance and enable a particular NASA mission - space laboratory-based microgravity experiments. To that end, a spectrum of technology is being developed in the disciplines of precision mechanisms and robotics. Author

N88-23238*# Carnegie-Mellon Univ., Pittsburgh, PA. Dept. of Mechanical Engineering.
BASE REACTION OPTIMIZATION OF MANIPULATORS WITH REDUNDANT KINEMATICS
C. L. CHUNG and S. DESA *In* NASA, Lewis Research Center Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 157-173 May 1988
(Contract NAG3-811)
Avail: NTIS HC A20/MF A01 CSCL 13I

A trajectory generation method for space manipulators is introduced. The approach developed employs a manipulator with redundant kinematics. The method is implemented in two steps. First, the end-effector trajectory is developed to satisfy motion requirements. Next, the joint trajectories are developed to minimize base reactions. The analytical development of this method is described and an example illustrating the method is presented. Author

N88-24147*# McDonnell-Douglas Astronautics Co., Houston, TX.
ADVANCED EVA SYSTEM DESIGN REQUIREMENTS STUDY
T. G. WOODS *In* NASA, Ames Research Center, Space Station Human Factors Research Review. Volume 1: EVA Research and Development p 85-130 Apr. 1988
Avail: NTIS HC A07/MF A01 CSCL 05H

The results are presented of a study to identify specific criteria regarding space station extravehicular activity system (EVAS) hardware requirements. Key EVA design issues include maintainability, technology readiness, LSS volume vs. EVA time available, suit pressure/cabin pressure relationship and productivity effects, crew autonomy, integration of EVA as a program resource, and standardization of task interfaces. A variety of DOD EVA systems issues were taken into consideration. Recommendations include: (1) crew limitations, not hardware limitations; (2) capability to perform all of 15 generic missions; (3) 90 days on-orbit maintainability with 50 percent duty cycle as minimum; and (4) use by payload sponsors of JSC document 10615A plus a Generic Tool Kit and Specialized Tool Kit description. EVA baseline design requirements and criteria, including requirements of various subsystems, are outlined. Space station/EVA system interface requirements and EVA accommodations are discussed in the areas of atmosphere composition and pressure, communications, data management, logistics, safe haven, SS exterior and interior requirements, and SS airlock. J.P.B.

N88-24191*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CONNECTING REMOTE SYSTEMS FOR DEMONSTRATION OF AUTOMATION TECHNOLOGIES
R. M. BROWN and R. YEE *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 15-23 Jun. 1988
Avail: NTIS HC A04/MF A01 CSCL 09B

An initial estimate of the communications requirements of the Systems Autonomy Demonstration Project (SADP) development and demonstration environments is presented. A proposed network paradigm is developed, and options for network topologies are explored. Author

N88-25155*# Maryland Univ., College Park. Biomechanics Lab.
THE EFFICACY OF USING HUMAN MYOELECTRIC SIGNALS TO CONTROL THE LIMBS OF ROBOTS IN SPACE Final Report, 15 Apr. 1987-1988
JANE E. CLARK and SALLY J. PHILLIPS 20 Jun. 1988 289 p
(Contract NAG5-895)
(NASA-CR-182901; NAS 1.26:182901) Avail: NTIS HC A13/MF A01 CSCL 05H

This project was designed to investigate the usefulness of the myoelectric signal as a control in robotics applications. More specifically, the neural patterns associated with human arm and hand actions were studied to determine the efficacy of using these myoelectric signals to control the manipulator arm of a robot. The advantage of this approach to robotic control was the use of well-defined and well-practiced neural patterns already available to the system, as opposed to requiring the human operator to learn new tasks and establish new neural patterns in learning to control a joystick or mechanical coupling device. Author

N88-25206*# Catholic Univ. of America, Washington, DC. Dept. of Electrical Engineering.
ANALYSIS OF A CLOSED-KINEMATIC CHAIN ROBOT MANIPULATOR Semiannual Report
CHARLES C. NGUYEN and FARHAD J. POORAN Jul. 1988 20 p
(Contract NAG5-780)
(NASA-CR-183031; NAS 1.26:183031) Avail: NTIS HC A03/MF A01 CSCL 09B

Presented are the research results from the research grant entitled: Active Control of Robot Manipulators, sponsored by the Goddard Space Flight Center (NASA) under grant number NAG-780. This report considers a class of robot manipulators based on the closed-kinematic chain mechanism (CKCM). This type of robot manipulators mainly consists of two platforms, one is stationary and the other moving, and they are coupled together through a number of in-parallel actuators. Using spatial geometry and homogeneous transformation, a closed-form solution is derived for the inverse kinematic problem of the six-degree-of-freedom manipulator, built to study robotic assembly in space. Iterative Newton Raphson method is employed to solve the forward kinematic problem. Finally, the equations of motion of the above manipulators are obtained by employing the Lagrangian method. Study of the manipulator dynamics is performed using computer simulation whose results show that the robot actuating forces are strongly dependent on the mass and centroid locations of the robot links. Author

N88-25472*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
DESIGN GUIDELINES FOR ROBOTICALLY SERVICEABLE HARDWARE
SCOTT A. GORDON Apr. 1988 23 p
(NASA-TM-100700; NAS 1.15:100700) Avail: NTIS HC A03/MF A01 CSCL 13I

Research being conducted at the Goddard Space Flight Center into the development of guidelines for the design of robotically serviceable spaceflight hardware is described. A mock-up was built based on an existing spaceflight system demonstrating how these guidelines can be applied to actual hardware. The report examines the basic servicing philosophy being studied and how this philosophy is reflected in the formulation of design guidelines for robotic servicing. A description of the mock-up is presented with emphasis on the design features that make it robot friendly. Three robotic servicing schemes fulfilling the design guidelines were developed for the mock-up. These servicing schemes are examined as to how their implementation was affected by the constraints of the spacecraft system on which the mock-up is based. Author

N88-26031# Methodist Hospital, Indianapolis, IN. Research and Development Dept.
THE US SPACE PROGRAMME SPACEWALK/EXTRAVEHICULAR ACTIVITY EXPERIENCE: PAST, PRESENT AND FUTURE
THOMAS P. MOORE *In* ESA, Proceedings of the Colloquium on Space and Sea p 115-120 Mar. 1988
Avail: NTIS HC A15/MF A01

The history and prospects of extravehicular activity (EVA) in NASA space programs are reviewed. The first EVA in the United States program took place on Gemini 4 in 1965. Lunar exploration was accomplished by 14 two-crewmember EVAs during the Apollo program which began in 1968. The United States' only long duration space flight experience took place in 1973 to 1974 aboard Skylab, with 10 EVAs being performed. Since the beginning of the Space Shuttle program in 1981, there have been 13 two-crewmember EVAs. Space Station is planned for component construction during EVAs for initial operation during the mid 1990s. Physiological effects on crews, particularly metabolic rate, are mentioned. ESA

N88-26038# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
SAFETY OF EXTRAVEHICULAR SPACE ACTIVITIES [SECURITE DES ACTIVITES SPATIALES EXTRA-VEHICULAIRES]
JACQUES LALOE *In* ESA, Proceedings of the Colloquium on Space and Sea p 161-168 Mar. 1988 In FRENCH
Avail: NTIS HC A15/MF A01

Factors which influence safety in space missions requiring extravehicular activity (EVA) are recalled. Research and development in EVA techniques are discussed. Life support systems; movement, mobility, and dexterity; interfaces; and crew procedures are considered. ESA

N88-26040# Institut Francais de Recherche pour l'Exploitation de la Mer, La Seyne sur Mer.
UNDERWATER SIMULATION FOR SPACE TELEOPERATION
J.-L. MICHEL and J.-F. DROGOU *In* ESA, Proceedings of the Colloquium on Space and Sea p 175-176 Mar. 1988
Avail: NTIS HC A15/MF A01

The use of water to simulate on land the conditions of microgravity encountered in space is reviewed. Neutral buoyancy is achieved underwater on submersibles and remotely operated vehicles but space simulation imposes specifically that the neutral buoyancy has also to be realized particularly on movable parts as telemanipulators. The physical properties of water limits the validity of the simulation to movements with very extremely low speed. Two vehicles realized for NASA are used to simulate vehicle mobility in docking phase and assembling teleoperations in water tanks. Knowing limitations and constraints, simulation in water offers the possibility to evaluate the relative efficiency of operations involving man and teleoperation on complex tasks. ESA

N88-26041# Norwegian Marine Technology Research Inst., Trondheim.
MARINTEK'S OCEAN BASIN, A TRAINING FACILITY FOR EXTRAVEHICULAR ACTIVITY?
TOR EINER BERG *In* ESA, Proceedings of the Colloquium on Space and Sea p 177-182 Mar. 1988
Avail: NTIS HC A15/MF A01

Equipment and functional requirements for a neutral buoyancy facility for weightlessness simulation are discussed. Time schedule and costs related to modification and upgrading of an ocean basin to become an extravehicular activity training facility for ESA are estimated. ESA

N88-26044# Centre National d'Etudes Spatiales, Toulouse (France).
TASKS FORESEEN FOR SPACE ROBOTS AND AN EXAMPLE OF AN ASSOCIATED ORBITAL INFRASTRUCTURE [TACHES ENVISAGEES POUR LES ROBOTS SPATIAUX ET EXEMPLE D'INFRASTRUCTURE ORBITAL ASSOCIEE]
PIERRE DUTTO *In* ESA, Proceedings of the Colloquium on Space and Sea p 199-208 Mar. 1988 In FRENCH
Avail: NTIS HC A15/MF A01

Robot activities on manned space stations are discussed and permanent installation of robots on automatic space platforms is considered. Robot interventions in dangerous areas such as spaceborne nuclear reactors and platforms subjected to high doses of radiation are treated. Robots on deep space probes are assessed. The actual and envisaged orbital infrastructures of the NASA, USSR, and European space programs are reviewed. ESA

N88-26045# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
MAN VERSUS MACHINE: THE ROLE OF ASTRONAUTS IN EXTRAVEHICULAR ACTIVITY

E. OLIER *In its* Proceedings of the Colloquium on Space and Sea p 213-218 Mar. 1988
Avail: NTIS HC A15/MF A01

Extravehicular acitivity (EVA) in NASA and USSR space programs is reviewed and European needs, particularly for the Columbus and Hermes programs, are assessed. It is suggested that remote manipulators and EVA are complementary, although EVA offers advantages once the work site is reached. ESA

N88-26398* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MOBILE REMOTE MANIPULATOR SYSTEM FOR A TETRAHEDRAL TRUSS Patent
CLARENCE J. WESSELSKI, inventor (to NASA) and WILLIAM C. SCHNEIDER, inventor (to NASA) 19 Jul. 1988 15 p Filed 5 Sep. 1986 Supersedes N87-15260 (25 - 07, p 0875) Sponsored by NASA
(NASA-CASE-MSC-20985-1; US-PATENT-4,757,767; US-PATENT-APPL-SN-904134; US-PATENT-CLASS-104-49; US-PATENT-CLASS-104-35; US-PATENT-CLASS-104-172.1; US-PATENT-CLASS-244-159) Avail: US Patent and Trademark Office CSCL 05H

The mobile remote manipulator system (MRMS) was initially developed for transit about the trusses of the delta space station; however, it can be utilized just as easily for transit about the trusses of the dual keel station. The MRMS is comprised of a mobile platform having a rail system formed of transversely disposed T-shaped tracks, which engage with guide pins located at the nodes of the trusses. The guide pins form a grid and the tracks are so designed as to permit travel in either of two orthogonal directions. The present invention provides a near-uniform traversing velocity with minimal dynamic loading on the system. Pivoting changers move the platform from one face to another.
Official Gazette of the U.S. Patent and Trademark Office

N88-26678# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
SIMULATION OF SPACE MANIPULATOR OPERATIONS (EUROSIM)
C. N. A. PRONK, A. ELFVING, E. ERSUE, and A. L. LIPPAY 13 Mar. 1987 10 p Presented at the Summer Computer Simulation Conference, Montreal, Quebec, 27-30 Jul. 1987
(Contract ESA-6482/85)
(NLR-MP-87017-U; B8805305; ETN-88-92609; PB88-209747; AD-B119669L) Avail: NTIS HC A02/MF A01

Definition and planning of application software for ESA's European Robotic Operations Simulator are reviewed. Simulation definition and test control software; overall system dynamic model; generic models for the in-orbit infrastructure, including spacecraft, environment, and payload; and mathematical models for the space manipulator system are discussed. A survey of existing models and software completed the requirements study. A plan for further development was specified. ESA

N88-29352*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION AS A VITAL FOCUS FOR ADVANCING THE TECHNOLOGIES OF AUTOMATION AND ROBOTICS
GIULIO VARSI (Jet Propulsion Lab., California Inst. of Tech., Pasadena.) and DANIEL H. HERMAN *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 1-6 Aug. 1988
(IAF-86-62) Avail: NTIS HC A99/MF E03 CSCL 22B

A major guideline for the design of the U.S. Space Station is that the Space Station address a wide variety of functions. These functions include the servicing of unmanned assets in space, the support of commercial labs in space and the efficient management of the Space Station itself; the largest space asset. The technologies of Automation and Robotics have the promise to help in reducing Space Station operating costs and to achieve a highly efficient use of the human in space. The use of advanced automation and artificial intelligence techniques, such as expert systems, in Space Station subsystems for activity planning and failure mode management will enable us to reduce dependency on a mission control center and could ultimately result in breaking the umbilical link from Earth to the Space Station. The application of robotic technologies with advanced perception capability and hierarchical intelligent control to servicing system will enable the servicing of assets either in space or in situ with a high degree of human efficiency. The results of studies leading toward the formulation of an automation and robotics plan for Space Station development are presented. Author

N88-29367*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
MACHINE VISION FOR REAL TIME ORBITAL OPERATIONS
FRANK L. VINZ *In its* Second Conference on Artificial Intelligence for Space Applications p 141-155 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

Machine vision for automation and robotic operation of Space Station era systems has the potential for increasing the efficiency of orbital servicing, repair, assembly and docking tasks. A machine vision research project is described in which a TV camera is used for inputing visual data to a computer so that image processing may be achieved for real time control of these orbital operations. A technique has resulted from this research which reduces computer memory requirements and greatly increases typical computational speed such that it has the potential for development into a real time orbital machine vision system. This technique is called AI BOSS (Analysis of Images by Box Scan and Syntax). Author

N88-29377*# Boeing Aerospace Co., Huntsville, AL. Space Station Program.
A PLAN FOR TIME-PHASED INCORPORATION OF AUTOMATION AND ROBOTICS ON THE US SPACE STATION
R. B. PURVES, P. S. LIN, and E. M. FISHER, JR. *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 237-245 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 22B

A plan for the incorporation of Automation and Robotics technology on the Space Station is presented. The time phased introduction of twenty two selected candidates is set forth in accordance with a technology development forecast. Twenty candidates were chosed primarily for their potential to relieve the crew of mundane or dangerous operations and maintenance burdens, thus freeing crew time for mission duties and enhancing safety. Two candidates were chosen based on a potential for increasing the productivity of laboratory experiments and thus directly enhancing the scientific value of the Space Station. A technology assessment for each candidate investigates present state of the art, development timelines including space qualification considerations, and potential for technology transfer to earth applications. Each candidate is evaluated using a crew workload model driven by crew size, number of pressurized U.S. modules and external payloads, which makes it possible to assess the impact of automation during a growth scenario. Costs for each increment of implementation are estimated and accumulated. Author

N88-29378*# Boeing Computer Services Co., Seattle, WA. Advanced Technology Center for Computer Sciences.
MOTION PLANNING FOR A FREE-FLYING ROBOT
DONALD LEO KAISER and PATRICK J. HAWKINS *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 247-255 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 22B

An investigation is presented of motion planning combining low level control and obstacle avoidance for a free flying robot. This free flying robot is an outgrowth of the concept of an assistant for astronauts on the U.S. Space Station and Shuttle. A motion planner based on the Khatib potential field approach is described. Because of the uncluttered environment in space, it generates a path from representation of known obstacles rather than from a representation of free space. A global planner supplies the low level controller with interim points between the current position and the desired goal position so that the vehicle does not become trapped by local minima, a phenomenon of the potential field approach. Discussion of the feasibility of this system for space applications is presented. Author

N88-29385*# Martin Marietta Aerospace, Denver, CO. Space Station Program.

INTELLIGENT RESOURCE MANAGEMENT FOR LOCAL AREA NETWORKS: APPROACH AND EVOLUTION

ROGER MEIKE *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 319-324 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

The Data Management System network is a complex and important part of manned space platforms. Its efficient operation is vital to crew, subsystems and experiments. AI is being considered to aid in the initial design of the network and to augment the management of its operation. The Intelligent Resource Management for Local Area Networks (IRMA-LAN) project is concerned with the application of AI techniques to network configuration and management. A network simulation was constructed employing real time process scheduling for realistic loads, and utilizing the IEEE 802.4 token passing scheme. This simulation is an integral part of the construction of the IRMA-LAN system. From it, a causal model is being constructed for use in prediction and deep reasoning about the system configuration. An AI network design advisor is being added to help in the design of an efficient network. The AI portion of the system is planned to evolve into a dynamic network management aid. The approach, the integrated simulation, project evolution, and some initial results are described. Author

N88-29387*# Georgia Inst. of Tech., Atlanta.

CONCEPTS FOR ROBOT MOTION PRIMITIVES REQUIRED FOR SPACE STATION TELEOPERATIONS

JEFFREY L. GROVER and STEVEN A. E. SUCHTING (Boeing Aerospace Co., Huntsville, Ala.) *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 337-346 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

Ground controlled teleoperations are expected to be used to augment Space Station manned extravehicular activities (EVA) and Intravehicular activities (IVA). However, ground controlled teleoperations will encounter communications time delays of from 3 to 8 secs. Time delays greater than 1 sec have been shown to be detrimental to safe and efficient teleoperations. Therefore, concepts must be developed to overcome the hazards and limitations of time delays when performing teleoperations using robots. The concept for robot motion primitives incorporate force/torque and tactile sensor feedback to implement the degree of autonomy required for interactive, ground controlled telerobotics. Several primitives are studied that augment human initiated actions by providing rapid response interaction with the physical environment of a telerobot. These primitives are detailed. They constitute a level of intelligent sensing and reaction required to augment human actions through autonomous interaction with the physical environment. Author

N88-29388*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

THE USE OF COMPUTER GRAPHIC SIMULATION IN THE DEVELOPMENT OF ROBOTIC SYSTEMS

KEN FERNANDEZ *In its* Second Conference on Artificial Intelligence for Space Applications p 347-354 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

The use of computer graphic simulation techniques to resolve critical design and operational issues for robotic systems is described. Use of this technology will result in greatly improved systems and reduced development costs. The major design issues in developing effective robotic systems are discussed and the use of ROBOSIM, a NASA developed simulation tool, to address these issues is presented. Three representative simulation case studies are reviewed: off-line programming of the robotic welding development cell for the Space Shuttle Main Engine; the integration of a sensor to control the robot used for removing the Thermal Protection System from the Solid Rocket Booster; and the development of a teleoperator/robot mechanism for the Orbital Maneuvering Vehicle. Author

N88-29405*# Martin Marietta Aerospace, Denver, CO. Space Station Program.

INTELLIGENT INTERFACE DESIGN AND EVALUATION

FRANK L. GREITZER *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 489-496 Aug. 1988 Sponsored in part by Martin Marietta Denver Aerospace Independent Research and Development
Avail: NTIS HC A99/MF E03 CSCL 09B

Intelligent interface concepts and systematic approaches to assessing their functionality are discussed. Four general features of intelligent interfaces are described: interaction efficiency, subtask automation, context sensitivity, and use of an appropriate design metaphor. Three evaluation methods are discussed: Functional Analysis, Part-Task Evaluation, and Operational Testing. Design and evaluation concepts are illustrated with examples from a prototype expert system interface for environmental control and life support systems for manned space platforms. Author

N88-29408*# Alabama Univ., Huntsville.

PERSONNEL OCCUPIED WOVEN ENVELOPE ROBOT

FRANCIS WESSLING, WILLIAM TEOH, and M CARL ZIEMKE *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 513-521 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

The Personnel Occupied Woven Envelope Robot (POWER) provides an alternative to extravehicular activity (EVA) of space suited astronauts and/or use of long slender manipulator arms such as are used in the Shuttle Remote Manipulator System. POWER provides the capability for a shirt sleeved astronaut to perform such work by entering a control pod through air locks at both ends of an inflated flexible bellows (access tunnel). The exoskeleton of the tunnel is a series of six degrees of freedom (Six-DOF) articulated links compressible to 1/6 of their fully extended length. The operator can maneuver the control pod to almost any location within about 50 m of the base attachment to the space station. POWER can be envisioned as a series of hollow Six-DOF manipulator segments or arms wherein each arm grasps the shoulder of the next arm. Inside the hollow arms ia a bellow-type access tunnel. The control pod is the fist of the series of linked hollow arms. The fingers of the fist are conventional manipulator arms under direct visual control of the nearby operator in the pod. The applications and progress to date of the POWER system is given. Author

N88-29409*# Boeing Aerospace Co., Huntsville, AL. Space Station Program.

REMOTE SERVICING OF SPACE SYSTEMS

S. L. COLLINS and R. B. PURVES *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 523-535 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

Space systems are difficult to maintain on orbit. The difficulty arises from the limited ability and availability of the astronaut work force in the hazardous space environment. Remote robotic manipulation can free the astronaut from the hazardous working environment while also increasing the work force. However, remote robotic servicing is not without its own set of problems and limitations, such as communication time delay and unstructured worksites. Tests and test equipment are described which are designed to increase the understanding of the remote servicing problems and to allow development of potential solutions. A half scale satellite mockup was developed for evaluating and improving upon the design of replaceable subsystems, such as batteries and electronic boxes. A servicer system, that includes a six degree of freedom PUMA 560 robot and interchangeable end effectors (tools), was developed to aid in driving out servicer design requirements. The results include the time delay impact on servicing timelines and requirements for the servicer system. Author

N88-29410*# Boeing Aerospace Co., Huntsville, AL. Space Station Program.
A TELEOPERATED ROBOTIC MANIPULATOR SYSTEM FOR MATERIALS PROCESSING EXPERIMENT SERVICING
STEVEN SUCHTING, R. BYRON PURVES, JEFFREY L. GROVER, and ROY SCRUGGS (Georgia Inst. of Tech., Atlanta.) *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 537-542 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

In 1984 Congress authorized NASA to begin the Space Station Program, and requested that 10 percent of program funds be spent in implementing automation and robotics (A and R) on the Space Station. In response to that request, Boeing established several Independent Research and Development (IR and D) projects to explore possible uses for A and R on the Space Station. One of those projects, and automated materials processing experiment, is discussed. The project uses a teleoperated robot to demonstrate telescience applied to a Chemical Vapor Transport materials processing experiment. Author

N88-29414*# Martin Marietta Aerospace, Denver, CO.
BLACKBOARD ARCHITECTURES AND THEIR RELATIONSHIP TO AUTONOMOUS SPACE SYSTEMS
ALLISON THORNBRUGH *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 583-589 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

The blackboard architecture provides a powerful paradigm for the autonomy expected in future spaceborne systems, especially SDI and Space Station. Autonomous systems will require skill in both the classic task of information analysis and the newer tasks of decision making, planning and system control. Successful blackboard systems have been built to deal with each of these tasks separately. The blackboard paradigm achieves success in difficult domains through its ability to integrate several uncertain sources of knowledge. In addition to flexible behavior during autonomous operation, the system must also be capable of incrementally growing from semiautonomy to full autonomy. The blackboard structure allows this development. The blackboard's ability to handle error, its flexible execution, and variants of this paradigm are discussed as they apply to specific problems of the space environment. Author

N88-29839# Erno Raumfahrttechnik G.m.b.H., Bremen (Germany, F.R.).
STUDY OF ROBOTICS SPACECRAFT SERVICING AND ASSEMBLY IN SPACE. VOLUME 1: EXECUTIVE SUMMARY Final Report
Paris, France ESA Feb. 1988 94 p Prepared in cooperation with Sener S.A., Madrid, Spain; Aeritalia S.p.A., Turin, Italy; Fraunhofer Inst. fuer Productionstechnik und Konstruktionstechnik, Berlin, Fed. Republic of Germany and Spar Aerospace Ltd., Ste-Anne-de-Bellevue, Quebec
(Contract ESA-6837/86-NL-PP(SC))
(ESA-CR(P)-2612-VOL-1; ETN-88-93147) Avail: NTIS HC A05/MF A01

The robotics, servicing, and assembly requirements of a microgravity mission and an orbital assembly mission were defined. The microgravity mission is based on the Man-Tended Free Flyer (MTFF) enhanced by additional elements, like an airlock, a multiberthing node, and an unpressurized payload area. The in-orbit assembly mission deals with the buildup of this enhanced version of the MTFF towards a European autonomous Space Station. For the micro-g mission the central transportation robot and a rack-dedicated manipulator are outlined as elements of an overall automation concept for the MTFF operation, while the in-orbit assembly mission identifies a moveable assembly manipulator for handling of modules and large structures. ESA

N88-30298# Selskapet for Industriell og Teknisk Forskning Trondheim (Norway). Div. of Medical Technology.
STUDY OF HUMAN FACTORS ENGINEERING CRITERIA FOR EXTRAVEHICULAR ACTIVITY (EVA) SYSTEMS, VOLUME 1 Final Report
A. O. BRUBAKK, B. HOLAND, G. BOLSTAD, A. PASCHE, T SYVERSEN, O. BJORSETH, H. RYVARDEN, H. FATHI, B BPEKKE, O. I. MOLVAER et al. Paris, France ESA 8 Dec 1987 333 p Sponsored in part by the Royal Norwegian Counci for Scientific and Industrial Research, Trondheim, Norway
(Contract ESTEC-7016/87-NL-PP(SC))
(STF23-F87025-VOL-1; ESA-CR(P)-2572-VOL-1; ETN-88-93020)
Avail: NTIS HC A15/MF A01

Human factors engineering for EVA: anthropometry; physiological and biochemical parameters at 1g conditions; physiological effects of the space environment; structural considerations; procedures; EVA suit design recommendations; EVA airborne support equipment; and EVA operational suppor equipment was reviewed. Design guidelines for man-machine interfaces for EVA systems are presented. Guidelines for astronau training for EVA are suggested. Simulation techniques for EVA development studies and training are considered. Training systems; neutral buoyancy facilities; and water tanks and diver test systems are discussed. ESA

N88-30357*# Jet Propulsion Lab., California Inst. of Tech. Pasadena.
THE SPACE STATION ASSEMBLY PHASE: SYSTEM DESIGN TRADE-OFFS FOR THE FLIGHT TELEROBOTIC SERVICER
JEFFREY H. SMITH, MAX GYAMFI, KENT VOLKMER, and WAYNE ZIMMERMAN *In* NASA, Goddard Space Flight Center, The 1988 Goddard Conference on Space Applications of Artificial Intelligence p 381-396 Aug. 1988
(Contract NAS7-918)
Avail: NTIS HC A19/MF A01 CSCL 05H

The effects of a recent study aimed at identifying key issues and trade-offs associated with using a Flight Telerobotic Servicer (FTS) to aid in Space Station assembly-phase tasks is described. The use of automation and robotic (A and R) technologies for large space systems often involves a substitution of automation capabilities for human EVA or IVA activities. A methodology is presented that incorporates assessment of candidate assembly-phase tasks, telerobotic performance capabilities, development costs, and effects of operational constaints. Changes in the region of cost-effectiveness are examined under a variety of system design assumptions. A discussion of issues is presented with focus on three roles the FTS might serve: as a research-oriented test bed to learn more about space usage of telerobotics; as a research based test bed having an experimental demonstration orientation with limited assembly and servicing applications; or as an operational system to augment EVA and to aid construction of the Space Station and to reduce the program (schedule) risk by increasing the flexibility of mission operations. Author

09

PROPULSION

Includes propulsion concepts and designs utilizing solar sailing, solar electric, ion, and low thrust chemical concepts.

A88-33441*# General Dynamics Corp., San Diego, CA.
LONG TERM ORBITAL STORAGE OF CRYOGENIC PROPELLANTS FOR ADVANCED SPACE TRANSPORTATION MISSIONS
JOHN R. SCHUSTER (General Dynamics Corp., Space Systems Div., San Diego, CA) and NORMAN S. BROWN (NASA, Marshall Space Flight Center, Huntsville, AL) IN: EASCON '87; Proceedings

of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 127-133.

A comprehensive study has developed the major features of a large capacity orbital propellant depot for the space-based, cryogenic OTV. The study has treated both the Dual-Keel Space Station and co-orbiting platforms as the accommodations base for the propellant storage facilities, and trades have examined both tethered and hard-docked options. Five tank set concepts were developed for storing the propellants, and along with layout options for the station and platform, were evaluated from the standpoints of servicing, propellant delivery, boiloff, micrometeoroid/debris shielding, development requirements, and cost. These trades led to the recommendation that an all-passive storage concept be considered for the platform and an actively refrigerated concept providing for reliquefaction of all boiloff be considered for the Space Station. The tank sets are modular, each storing up to 45,400 kg of LO2/LH2, and employ many advanced features to provide for microgravity fluid management and to limit boiloff. The features include such technologies as zero-gravity mass gauging, total communication capillary liquid acquisition devices, autogenous pressurization, thermodynamic vent systems, thick multilayer insulation, vapor-cooled shields, solar-selective coatings, advanced micrometeoroid/debris protection systems, and long-lived cryogenic refrigeration systems. Author

A88-33792#

TESTING OF PROPELLANT MANAGEMENT DEVICE FOR 3-AXIS GEOSYNCHRONOUS SPACECRAFT

TSO-PING YEH and DONALD L. BOND (Ford Aerospace and Communications Corp., Palo Alto, CA) IN: Aerospace Testing Seminar, 10th, Los Angeles, CA, Mar. 10-12, 1987, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1987, p. 137-141.

Testing on scale models, components, and subassemblies and on the integrated tank is being used to qualify a propellant tank for Ford Aerospace's new class of geosynchronous satellites. Experimental methods used to simulate fluid behavior, including drop tower and zero-g KC-135 aircraft flights, are discussed and correlated to analytical models. The testing planned during the PMD assembly, tank qualification, and acceptance testing while in the normal one-g environment is discussed. Author

A88-35100

EXOTIC PROPULSION IN THE 21ST CENTURY

ROBERT L. FORWARD (Hughes Research Laboratories, Malibu, CA) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 717-744. refs
(Contract F04611-86-C-0039)
(AAS PAPER 86-409)

Possible forms of interplanetary spacecraft propulsion for next-century development and implementation are presented and comparatively evaluated, with a view to the types of technology involved. Both Western and Soviet proposals are discussed. The propulsion system types are (1) laser thermal; (2) 'Skyhook' and 'rotavator' propulsion tethers; (3) proton-antiproton annihilation; (4) solar radiation-pushed light sails; and (5) laser radiation-pushed light sails. Laser-pushed light sails are held to be capable of supporting round-trip interstellar travel. O.C.

A88-35943#

DESIGN OF LIGHT-WEIGHT IMPACT RESISTANT PRESSURE VESSELS FOR SPACE STATION FLUID AND PROPULSION SYSTEMS

K. A. MCCLYMONDS, H. W. BABEL, and D. P. RYAN (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 7 p. Research supported by McDonnell Douglas Astronautics Co. refs
(AIAA PAPER 88-2466)

The Space Station requires many gas storage tanks to operate the fluid management and distribution systems, and propulsion systems. Composites are attractive candidates for pressure containment based on their high specific tensile strengths. This work addresses the issues for such tanks and focuses on the critical problem of meeting leak-before-burst requirements for hypervelocity particle impacts. Test data is reported for 30 caliber gunfire and hypervelocity impacts on graphite/epoxy overwrapped bottles with aluminum liners. Author

A88-41283

BEYOND LOW EARTH ORBIT - A SURVEY OF UPPER STAGES

DAVID W. THOMPSON (Orbital Sciences Corp., Fairfax, VA) IN: Visions of tomorrow: A focus on national space transportation issues; Proceedings of the Twenty-fifth Goddard Memorial Symposium, Greenbelt, MD, Mar. 18-20, 1987. San Diego, CA, Univelt, Inc., 1987, p. 131-136.
(AAS PAPER 87-115)

An account is given of foreseeable prospects for relatively near-term supplements to the U.S.'s OTV inventory. This inventory currently encompasses the Payload Assist Module, the Inertial Upper Stage, and the Transfer Orbit Stage (TOS). Prospective systens are the Orbital Maneuvering Vehicle, which is an autonomous modular bipropellant vehicle; the TOS/Apogee and Maneuvering Stage, which would be capable of placing 65,000 lbs into GEO on the basis of derivative technology; the Adaptable Space Propulsion System, which would be compatible with the Titan 4 launcher; the Aeroassist Flight Experiment of NASA's Civil Space Technology Initiative; and the Orbital Transfer Vehicle, which will be both man-rated and reusable. O.C.

A88-41287

LEO TO GEO TRANSPORTATION SYSTEM COMBINING ELECTRIC PROPULSION WITH BEAMED MICROWAVE POWER FROM EARTH

WILLIAM C. BROWN (Microwave Power Transmission Systems, Inc., Weston, MA) IN: Visions of tomorrow: A focus on national space transportation issues; Proceedings of the Twenty-fifth Goddard Memorial Symposium, Greenbelt, MD, Mar. 18-20, 1987. San Diego, CA, Univelt, Inc., 1987, p. 195-217. refs
(AAS PAPER 87-126)

Transportation of space payloads aboard OTVs from LEO to GEO is presently envisioned with a system combining electric propulsion with beamed microwave power from earth, via a rectenna that both absorbs and rectifies the microwave beam focused on the vehicle by an electronically steerable phased array. The rectenna's mass, at 1 kg/kW, is an order of magnitude lower than other proposed space power sources. The transmitters are located on the equator, and the OTVs are launched into an equatorial-plane orbit, so that the beam can sweep a large angle west-to-east. Microwave OTVs are compared with a nuclear propulsion alternative; these technologies are noted to be complementary for large scale lunar and Martian missions. O.C.

A88-43710#

OPEN-CYCLE CHEMICAL POWER AND THERMAL MANAGEMENT SYSTEM WITH COMBUSTION PRODUCT-FREE EFFLUENT

G. S. HOSFORD, K. WEBER (Sundstrand Corp., Rockford, IL), and R. GIELLIS (Martin Marietta Corp., Denver, CO) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 6 p.
(AIAA PAPER 88-2625)

Open-cycle chemical prime power sources offer a nonnuclear alternative for satisfying the burst electrical power requirements for space-based multimegawatt power concepts. Although hydrogen-oxygen chemical energy sources require long-term cryogenic storage technology, they have less mass than systems that use fuels and oxidizers that can be stored at temperatures found in the low earth orbit environment. Open-cycle chemical concepts typically exhaust undesirable products of combustion into the environment surrounding space platforms. Innovative application of thermophysical principles in a new open-cycle chemical power generation concept prevents these combustion products from entering the exhaust gas stream and provides a means of storing them in a liquid state on the platform. This concept eliminates one of the major disadvantages of the open-cycle chemical systems. Author

A88-43863

HEAVY LIFT HORIZONTAL TAKE-OFF AND LANDING VEHICLES

A. W. SWALES British Interplanetary Society, Journal (ISSN 0007-084X), vol. 41, June 1988, p. 255-261. refs

The growth potential of the Hotol concept as applied to the transport of large heavy structures to orbit is discussed. Special consideration is given to the 'Caret' wind concept, which makes it possible to use athmosphere for lift. A performance analysis of the wing design is presented together with the analysis of the mass budget and fuel requirements for single-stage-to-orbit and two-stage-to-orbit orbiter and glider arrangements. It is shown that such a vehicle is a viable prospect and a good candidate for shared development as an intercontinental transport. I.S.

A88-44668*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

PARAMETRIC STUDIES OF ELECTRIC PROPULSION SYSTEMS FOR ORBIT TRANSFER VEHICLES

R. MANVI and T. FUJITA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. DOE-DOD-sponsored research. refs
(AIAA PAPER 88-2835)

The present parametric tradeoff study for OTV electric propulsion systems encompasses ammonia and hydrogen arcjets as well as Xe-ion propulsion systems with performance characteristics currently being projected for 1993 operation. In all cases, the power source is a nuclear-electric system with 30 kg/kW(e) specific mass, and the mission involves the movement of payloads from lower orbits to GEO. Attention is given to payload capabilities and associated propellant requirements. Mission trip time is identified as the key parameter for selection; while arcjets are preferable for shorter trip times, ion propulsion is more advantageous for longer trip times due to reduced propellant mass fraction. O.C.

A88-44698*# National Aeronautics and Space Administration, Washington, DC.

PROPULSION SAFETY ALMOST EQUALS MISSION SAFETY

GILBERT L. ROTH (NASA, Washington, DC) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 5 p. refs
(AIAA PAPER 88-2881)

Propulsion system hardware and monitoring/control software constitute a given manned or unmanned aerospace system's primary risk-management issue. The present inquiry into the reasons for this dominance attempts to identify development routes to the reduction of propulsion-related management risk issues. A 'life management plan' for propulsion systems would give attention to service life requirements, criteria for the monitoring and evaluation of useful life, a method for the tracking of service life, criteria for hardware reusability and operations inspection, and hardware preassembly screening practices. O.C.

A88-44820*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF TEST-CELL PRESSURE ON THE PERFORMANCE OF RESISTOJETS

D. H. MANZELLA (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH), P. F. PENKO (NASA, Lewis Research Center, Cleveland, OH), K. J. DE WITT, and T. G. KEITH, JR. (Toledo, University, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. NASA-supported research. refs
(AIAA PAPER 88-3286)

The effect of test-cell pressure on the performance of two resistojets was investigated. Tests were conducted in a vacuum facility at pressures ranging from 0.000043 to 0.54 torr for two resistojet configurations: a laboratory model and an engineering model for the Space Station. The tests showed that for each thruster there was a decline in performance when tested in vacuum pressures above 0.001 torr. Measurements were made of surface temperature, thrust, and exit-plane pitot pressure over the range of test-cell pressures. From these measurements, the decline in performance of the laboratory-model resistojet at higher cell pressures was attributed to heat losses due to convection. For the engineering-model resistojet, the decline in performance was found to be a combination of heat loss and an effect of cell pressure on the nozzle flow. Author

A88-44875#

ALL ELECTRONIC PROPULSION - KEY TO FUTURE SPACESHIP DESIGN

WILLIAM C. BROWN (Microwave Power Transmission Systems, Weston, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 20 p. refs
(AIAA PAPER 88-3170)

The all-electronic propulsion system combines the high specific impulse of the ion thruster with beamed microwave power to produce a combined power and propulsion system with a self-acceleration as greater at 0.02 m/sec sq with a specific impulse of 4200. This is more than an order of magnitude greater than that provided by other approaches to electric propulsion in their current state of development, including nuclear and photovoltaic power sources. Associated with this new technology are two requirements for its execution: (1) the space vehicles and earth based transmitters must be based in the equatorial plane; and (2) the vehicles are large in area and have very high thrust levels because of efficiency and cost considerations associated with the microwave beam system. These vehicles, both in size and physical configuration, are different from conventional space vehicles and may have an impact upon future space vehicle design including those using photovoltaic power. Author

A88-46489*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ADVANCED PROPULSION FOR THE MARS ROVER SAMPLE RETURN MISSION

BRYAN PALASZEWSKI and ROBERT FRISBEE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. refs
(AIAA PAPER 88-2900)

The present evaluation of highly detailed advanced propulsion system design concepts for the Mars Rover Sample Return Mission proceeded by comparing a baseline chemical propulsion option with both storable and cryogenic advanced chemical propulsion alternatives and solar- and nuclear-based electric propulsion OTVs. Substantial launch mass reductions and commensurate payload mass increases were obtainable with both advanced chemical and electric propulsion cycles. O.C.

A88-48042#

SOLAR THERMAL PROPULSION FOR ORBIT TRANSFER

JAMES M. SHOJI and PATRICK E. FRYE (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference and Exhibit, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(AIAA PAPER 88-3171)

A preliminary analysis of pressure-fed and pump-fed solar thermal propulsion systems revealed that a pressure-fed system using cold helium is a much simpler system; however, the resulting payload is too great. In the case of a LEO-to-GEO mission, an optimum thrust level was obtained for the solar thermal propulsion system. For the two-engine concepts considered, the optimum thrust was in the 30 to 45 lbf thrust range. The engine concept providing the higher specific impulse resulted in a lower optimum thrust level. K.K.

A88-48484#

AN ANALYSIS OF ORBIT MANEUVERING CAPABILITIES USING ARCJET PROPULSION

R. J. CASSADY (Rocket Research Co., Redmond, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 6 p. refs
(AIAA PAPER 88-2832)

The thermal arcjet thruster is a leading candidate for several geocentric orbit transfer and maneuvering missions. The objective of this paper is to catalog those missions and perform an analysis for a representative case of the various mission types which will serve to illustrate the expanded capabilities provided by arcjet propulsion. Recent literature sources mention arcjets in conjunction with three classes of missions: N-S stationkeeping of geosynchronous satellites, orbit maneuvering of intermediate orbit satellites, and orbit transfer from Low Earth Orbit (LEO) to higher orbits. These will be considered as the baseline set of missions to be analyzed. In addition, the use of arcjet propulsion as an upper stage of a chemical/electric Orbit Transfer Vehicle (OTV) will be considered, as well as other variations on the basic mission set. Author

A88-48492*# Martin Marietta Corp., Denver, CO

INTEGRATION OF SPACE STATION PROPULSION AND FLUID SYSTEMS

B. A. BICKNELL, D. A. FESTER, and S. C. WILSON (Martin Marietta Corp., Denver, CO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. refs
(Contract NAS8-36438)
(AIAA PAPER 88-3289)

The benefits which would be gained by providing commonality and integration of propulsion and fluid systems associated with various elements of the Space Station are discussed and the results of the integrated propulsion system assessment are presented. The O2/H2 propulsion system with and without resistojets, the integration of O2/H2 systems across the Space Station elements, and an approach for handling waste fluids available for resistojet venting are evaluated. It is shown that major benefits can be gained through commonality and integration. Several systems are recommended, including a gaseous O2/H2 propulsion system with resistojets, a Bosch CO2 reduction process, and pumping electrolysis units. R.B.

A88-49750

PERFORMANCE OF FOCUSING MIRROR SYSTEMS FOR THE SOLAR DYNAMIC ENERGY SUPPLY OF SPACE STATIONS [ZUR LEISTUNG KONZENTRIERENDER SPIEGELSYSTEME FUER DIE SOLARDYNAMISCHE ENERGIE VERSORGUNG VON RAUMSTATIONEN]

R. KOEHNE (DFVLR, Institut fuer technische Thermodynamik, Stuttgart, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, May-June 1988, p. 197-201. In German. refs

Solar dynamic systems consisting of focusing solar collectors and heat engines are attracting increasing interest for space stations because of their high efficiencies. The optical and thermal performances of various collecting mirrors and collecting mirror systems is determined by computer modeling and the effect of manufacturing and tracking errors is indicated. Sufficiently high thermal collector efficiencies from 60 to 75 percent over a 600-1200 C temperature range can be attained with low total error below 4 mrad. C.D.

A88-49825#

THE USE OF PYROTECHNICS ON SPACECRAFT

N. CABLE (ESA, Structures and Mechanisms Div., Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 54, May 1988, p. 66-71.

Because of their extremely high energy-to-volume densities, explosives are an invaluable tool aboard spacecraft for single-operation functions. Highly reliable and safe actuators have been developed to exploit this useful property for a variety of applications, using only standard spacecraft supplies and controls. Author

A88-50425#

ANALYTICAL MODELS FOR RELATIVE MOTION UNDER CONSTANT THRUST

J. VAN DER HA and R. MUGELLESI (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 636-644. refs
(AIAA PAPER 88-4300)

A general formulation for relative motion is presented allowing for arbitrary perturbing or thrust forces on each of the two satellites. Exact as well as approximate perturbation solutions for the relative motion under constant radial or circumferential forces acting on the subsatellite are established. The validity and usefulness of these solutions is assessed for a few realistic applications related to Eureca rendezvous maneuvering with the Shuttle. The results are of general interest for the fast calculation of relative subsatellite motion under thrust forces. Author

A88-50671

POSSIBLE VARIANTS OF MICROWAVE-BEAM STRUCTURE FOR SATELLITE SOLAR POWER PLANTS [O VOZMOZHNYKH VARIANTAKH STRUKTURY SVCH-PUCHKA SOLNECHNYKH KOSMICHESKIKH ENERGOSISTEM]

V. A. VANKE, S. K. LESOTA, and A. V. RACHNIKOV Radiotekhnika i Elektronika (ISSN 0033-8494), vol. 33, July 1988, p. 1531-1536. In Russian. refs

An analysis is made of the maximum efficiency of the microwave-beam transmission channel in a satellite solar power system that can be realized for a discrete 10-step amplitude distribution of the transmitting-antenna field. High-efficiency variants of the channel structure are found which are characterized by a high mean field intensity on the receiving antenna and an increased overall level of transmitted power for fixed values of maximum power density on the transmitting and receiving antennas. B.J.

A88-50769

HIGH-TEMPERATURE SOLAR ENERGY SYSTEMS FOR SPACECRAFT POWER AND PROPULSION UNITS [SOLNECHNYE VYSOKOTEMPERATURNYE KOSMICHESKIE ENERGODVIGATEL'NYE USTANOVKI]

OLEG IVANOVICH KUDRIN Moscow, Izdatel'stvo Mashinostroenie, 1987, 248 p. In Russian. refs

The work covers such topics as solar-energy concentrators, concentrator-receiver systems in solar-energy propulsion units, selective absorption as a way to enhance the efficiency of solar energy conversion and the Stirling engine as a solar enery converter. The development of high-temperature solar energy systems for spacecraft power and propulsion units is investigated in detail, with particular attention given to results of ground-based testing. K.K.

A88-51139

DEBRIS IN SPACE

TIM FURNISS Flight International (ISSN 0015-3710), vol. 134, July 30, 1988, p. 28-31.

Orbital satellite and debris traffic continues to grow by about 300 items/year in 'permanent' orbits from which satellites cannot directly reenter the earth's atmosphere. There are in addition over 30,000 marble-to-baseball-sized objects, trillions of small paint flakes, and tens of thousands of trillions of still-smaller aluminum oxide dust particles; these are impossible to track, and may in the case of paint flake-sized objects result in the death of an astronaut during EVAs. An evaluation is presently made of the prospects for a debris hazard-exacerbating 'cascade' effect, in which the debris population grows to the point where collisions trigger a chain reaction of fragmentations. O.C.

A88-52373

SHUTTLE-C - A SHUTTLE DERIVED LAUNCH VEHICLE

TERRY R. MITCHELL IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 12-1 to 12-12.

The cargo version of the NASA Space Shuttle, designated 'Shuttle-C', uses the main engines, solid rocket boosters, external tanks, and launch facilities of the standard vehicle, replacing the manned Orbiter with an unmanned cargo carrier capable of placing payloads weighing 100,000-150,000 lbs into LEO; this compares with a 65,000-lb capability for the standard Shuttle. Shuttle-C will be used to launch and assemble such structures as those of the Space Station, as well as for the launching of large planetary probe payloads requiring heavy upper stages. Initial operation is projected to lie in the 1994 time-frame. O.C.

A88-52374#

OPERATIONAL CAPABILITIES OF GENERIC ADVANCED LAUNCH SYSTEM CONCEPTS

B. P. LEONARD and W. A. KISKO (L Systems, Inc., El Segundo, CA) Canaveral Council of Technical Societies, Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Paper. 48 p.

The present study of generic Advanced Launch Systems (ALS) concepts under consideration in the U.S. defines these concepts, and projects the values of their operational parameters on the basis of the launch histories of the Titan and Delta launcher families. Monte Carlo simulations are then conducted to predict their operational characteristics and capabilities; the operational criteria subsequently defined are applied to assess the generic ALS concepts' comparative advantages. It is concluded that an expendable system should have better operational capabilities than a recoverable one. O.C.

A88-53101*# Rockwell International Corp., Canoga Park, CA.

25-LBF GO2/GH2 SPACE STATION THRUSTER

L. E. FINDEN, G. L. BRILEY, and R. S. IACABUCCI (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p.

(Contract NAS3-25142; NAS8-36418)

(AIAA PAPER 88-2793)

Multiple 25-lbf oxygen/gaseous hydrogen thruster assemblies for the Space Station propulsion application were designed and fabricated by Rocketdyne and endurance tested at the NASA/Marshall Space Flight Center. The thrusters incorporate a regeneratively cooled thrust chamber with a nozzle area ratio of 30, a 12-element coaxial injector, an ignition system, and close-coupled propellant valves. The various thruster configurations comprised of mating different injectors and thrust chambers. Over 2 million lbf-sec of impulse was demonstrated at mixture ratios from 3 to 8.4 at vacuum conditions. A thruster was subjected to over 10,000 pulses during which minimum impulse bits of less than 0.5 lb/sec were repeatedly and reliably demonstrated. A total operating time of 25.6 hr was accumulated on the thruster assemblies with one 6.1-hr. continuous firing duration. The thrusters operated between a thrust range of 11.2 and 36.6 lbf. The test results indicate that all major technology issues for long-life gaseous oxygen/gaseous hydrogen thrusters for the Space Station application have been resolved. Author

A88-53163#

FUNDAMENTAL LIMITATIONS ON LOW GRAVITY FLUID GAUGING TECHNOLOGIES IMPOSED BY ORBITAL MISSION REQUIREMENTS

R. JOHN HANSMAN, JR. (MIT, Cambridge, MA) and JERE S. MESEROLE (Boeing Aerospace Co., Kent, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. Research supported by Boeing Aerospace Co. refs

(AIAA PAPER 88-3402)

The limitations on low gravity fluid gauging technologies imposed by fluid behavior resulting from the orbital environment is investigated. While there are numerous potential techniques, they are all expected to suffer some degradation under certain low gravity conditions. Specific current and proposed low gravity fluid gauging technologies are briefly reviewed. The impact on these technologies of low gravity modes of fluid behavior including ambiguous orientation, bubble entrapment, sensor wetting, sensor blocking and reduced convection are discussed. Potential techniques to improve low gravity fluid gauging are discussed including Bond number enhancement, tank and sensor design considerations. In addition, system design considerations are discussed including sensor integration, dynamic measurement techniques and mission design concepts. Author

A88-54696

DIGITAL SEQUENTIAL SHUNT REGULATOR FOR SOLAR POWER CONDITIONING OF ENGINEERING TEST SATELLITE (ETS-V)

SABURO KUWAJIMA, TETSUO SATO, MOTOHIRO KOBAYASHI, TOSHIO OKAMURA (National Space Development Agency of Japan, Tsukuba), NAOKI TSUYA (Mitsubishi Electric Corp., Kamakura, Japan) et al. IN: PESC '88 - Annual IEEE Power Electronics Specialists Conference, 19th, Kyoto, Japan, Apr. 11-14, 1988, Record. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 619-625. refs

A digital sequential shunt regulator is presented that regulates the bus voltage of the high-power ETS-V by controlling solar array segments sequentially in an on-off switching manner. To reduce EMI generated from switching surge current, a current-limiting circuit has been designed, and its effectiveness is verified experimentally. Static and dynamic characteristics of the voltage regulation loop are analyzed, and results are in good agrement with experimental results. I.E.

A88-55365#

USE OF THE SURFACE TENSION PROPELLANT TANKS IN THE INDIAN SATELLITE INSAT

G. NETTER (MBB-ERNO, Bremen, Federal Republic of Germany) and C. S. PRASAD (ISRO, Liquid Propulsion Systems Centre, Bangalore, India) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 10 p.

(IAF PAPER 88-237)

The main features of Insat-II, a multipurpose Indian geostationary satellite designed to provide services in communication, TV, and meteorology, are described. The propulsion system is bipropellant, operating on MMH and MON-3 liquids. Particular attention is given to the satellite's passive propellant management devices. K.K.

N88-21188*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SPACE STATION HEAVY LIFT LAUNCH VEHICLE UTILIZATION Technical Memorandum, Jan. - Dec. 1987

L. J. DERYDER Apr. 1988 177 p

(NASA-TM-100604; NAS 1.15:100604) Avail: NTIS HC A09/MF A01 CSCL 22B

The use of Heavy Lift Launch Vehicles (HLLVs) for Space Station assembly, logistics, and resupply is explored. Potential HLLVs, including those based on the Titan, and Shuttle-derived vehicles (SDV), are discussed. The baseline Critical Evaluation Task Force (CETF) Space Station assembly sequence is described and compared with assembly options made possible through the use of HLLVs. The issues of cost, dual compatibility with the Space Shuttle Space Transportation System (STS), co-manifesting of payloads with other science missions cargo return, and ground handling and launch facilities are also considered. The main advantage achieved by using HLLVs are simplification of assembly procedures, added resupply capability, and increased assured access to space. The major disadvantages are increased orbital flight operations complexity, higher logistics costs, and additional ground handling/launch facility requirements. Also, there will not be any improvement in return cargo capacity, nor any addition to crew transport capabilities. Finally, the dual STS/HLLV compatibility should be maintained to minimize program risk. HLLV and Orbital

Maneuvering Vehicle design must parallel that of the Space Station. Author

N88-24154*# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France).

FAULT DIAGNOSIS IN ORBITAL REFUELING OPERATIONS

GUY A. BOY *In* NASA, Ames Research Center, Space Station Human Factors Research Review. Volume 4: Inhouse Advanced Development and Research p 89-112 May 1988

Avail: NTIS HC A07/MF A01 CSCL 22B

Usually, operation manuals are provided for helping astronauts during space operations. These manuals include normal and malfunction procedures. Transferring operation manual knowledge into a computerized form is not a trivial task. This knowledge is generally written by designers or operation engineers and is often quite different from the user logic. The latter is usually a compiled version of the former. Experiments are in progress to assess the user logic. HORSES (Human - Orbital Refueling System - Expert System) is an attempt to include both of these logics in the same tool. It is designed to assist astronauts during monitoring and diagnosis tasks. Basically, HORSES includes a situation recognition level coupled to an analytical diagnoser, and a meta-level working on both of the previous levels. HORSES is a good tool for modeling task models and is also more broadly useful for knowledge design. The presentation is represented by abstract and overhead visuals only. Author

N88-24261*# General Electric Co., Philadelphia, PA. Spacecraft Operation.

NUCLEAR ELECTRIC POWER FOR MULTIMEGAWATT ORBIT TRANSFER VEHICLES

R. D. CASAGRANDE *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 27-30 1987 Sponsored by NASA, Lewis Research Center, Cleveland, Ohio, AFOSR, Bolling AFB, Washington, D.C. and AFRPL, Edwards AFB, Calif.

(Contract F29601-86-C-0238)

Avail: NTIS HC A22/MF A01 CSCL 09C

Multimegawatt nuclear propulsion is an attractive option for orbit transfer vehicles. The masses of these platforms are expected to exceed the capability of a single launch from Earth necessitating assembly in space in a parking orbit. The OTV would transfer the platform from the parking orbit to the operational orbit and then return for the next mission. Electric propulsion is advantageous because of the high specific impulse achieved by the technology, 1000 to 5000 s and beyond, to reduce the propellant required. Nuclear power is attractive as the power system because of the weight savings over solar systems in the multimegawatt regime, and multimegawatts of power are required. A conceptual diagram is shown of an OTV with a command control module using electric thrusters powered from an SP-100 class nuclear reactor power system. Author

N88-24272# Brookhaven National Lab., Upton, NY. Dept. of Nuclear Energy.

NUCLEAR PROPULSION SYSTEMS FOR ORBIT TRANSFER BASED ON THE PARTICLE BED REACTOR

J. R. POWELL, H. LUDEWIG, F. L. HORN, K. ARAJ, R. BENENATI, O. LAZARETH, G. SLOVIK, M. SOLON, W. TAPPE, J. BELISLE (Grumman Aerospace Corp., Bethpage, N.Y.) et al. *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 73-76 1987 Previously announced as N87-28405 Sponsored by AFRPL, Edwards AFB, Calif.

Avail: NTIS HC A22/MF A01

The technology of nuclear direct propulsion orbit transfer systems based on the Particle Bed Reactor (PBR) is described. A 200 megawatt illustrative design is presented for LEO to GEO and other high V missions. The PBR-OTV can be used in a one-way mode with the shuttle or an expandable launch vehicle, e.g., the Titan 34D7, or as a two-way reusable space tug. In the one-way mode, payload capacity is almost three times greater than that of chemical OTV's. PBR technology statis is described and development needs outlined. E.R.

N88-24379# Idaho National Engineering Lab., Idaho Falls.

COMPARISON OF A DIRECT THRUST NUCLEAR ENGINE, NUCLEAR ELECTRIC ENGINE AND A CHEMICAL ENGINE FOR FUTURE SPACE MISSIONS

JACK H. RAMSTHALER and TAL K. SULMEISTERS (Martin Marietta Corp., Englewood, Colo.) *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 19-22 1988

(Contract DE-AC07-76ID-01570)

Avail: NTIS HC A99/MF A01

The need for an advanced direct thrust nuclear rocket propulsion engine was identified in Project Forecast 2, Air Force Systems Command report on its future needs. The AF Astronomical Lab (AFAL) has the responsibility to develop the nuclear engine. The Idaho National Engineering Lab (INEL) will collaborate with Martin Marietta to stage design and mission analyses. Science Applications International (SAIC) will do flight safety analysis. Westinghouse will design the nuclear subsystem, and Rocketdyne the engine. INEL is overall manager for program and test facility design, construction and operation. INEL has produced plans for both engine system and ground test facility. AFAL has funded INEL to perform mission analyses and to evaluate cost, performance and operational advantages for a direct thrust nuclear rocket stage in performing AF Space missions. The Advanced Nuclear Rocket Engine (ANRE), a scaled down NERVA derivative, was used as a baseline for comparison with chemical engines and nuclear electric engines for completion of orbital transfer and maneuver missions. Life cycle costs of the three systems are estimated, based on delivery of a 6350 kg payload from LEO to geosynchronous orbit and back to LEO. Author

N88-24444# Air Force Astronautics Lab., Edwards AFB, CA.

NONCRYOGENIC PROPELLANTS FOR A NUCLEAR ORBIT TRANSFER VEHICLE

RYAN K. HAALAND and ANDREW MARTIN *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 341-344 1988

Avail: NTIS HC A99/MF A01

Recently imposed limitations regarding venting propellants in the STS payload bay may severely limit the capability to place heavier payloads in geosynchronous orbit by not allowing the use of current cryogenic propulsion systems. The two propulsion systems considered represent a wide range of nuclear reactor technology. The Small Nuclear Rocket Engine (SNRE) is derived from the Rover/NERVA program. The particle bed propulsion system represents a yet unproven reactor design offering a significant reduction in mass. Both systems are assumed to have the same operating conditions, approximately 250 Mwt, a chamber temperature of 2770 K, and a chamber pressure of 10.1 MPa. It is concluded that nuclear propulsion systems using various noncryogenic propellants offer a viable option for increasing the payload to GEO capability of the STS. The use of propellants that do not require venting, that is noncryogenic, coupled with a nuclear fission reactor should allow the development of high performance nuclear propulsion systems that meet STS payload safety requirements. A major concern is the effect of the noncryogenic propellants on the reactor concepts. Author

N88-24681# Edgerton, Germeshausen and Grier, Inc., Idaho Falls, ID.

ADVANCED NUCLEAR ROCKET ENGINE MISSION ANALYSIS

J. RAMSTHALER, G. FARBMAN, T. SULMEISTERS, D. BUDEN, and P. HARRIS (Rockwell International Corp., Canoga Park, Calif.) Dec. 1987 11 p Presented at the JANNAF Propulsion Conference, San Diego, Calif., 15 Dec. 1987

(Contract DE-AC07-76ID-01570)

(DE88-006797; EGG-M-41087; CONF-871274-1) Avail: NTIS HC A03

The use of a derivative of the NERVA engine developed from 1955 to 1973 was evaluated for potential application to Air Force orbital transfer and maneuvering missions in the time period 1995 to 2020. The NERVA stge was found to have lower Life Cycle Costs (LCC) than an advanced chemical stage for performing Low

Earth Orbit (LEO) to geosynchronous orbit (GEO) missions at any level of activity greater than three missions per year. It had lower life cycle costs than a high performance nuclear electric engine at any level of LEO to GEO mission activity. An examination of all unmanned orbital transfer and maneuvering missions from the Space Transportation Architecture Study (STAS 111-3) indicated a LCC advantage for the NERVA stage over the advanced chemical stage of fifteen million dollars. The cost advance accured from both the orbital transfer and maneuvering missions. Parametric analyses showed that the specific impulse of the NERVA stage and the cost of delivering material to low earth orbit were the most significant factors in the LCC advantage over the chemical stage. Lower development costs and a higher thrust gave the NERVA engine an LCC advantage over the nuclear electric stage DOE

N88-28084*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

SUPERFLUID HELIUM ON-ORBIT TRANSFER (SHOOT) OPERATONS

P. KITTEL and M. J. DIPIRRO Jul. 1988 19 p Presented at the Space Cryogenics Workshop, Frascati, Italy, 18-19 Jul. 1988 Prepared in cooperation with NASA. Goddard Space Flight Center, Greenbelt, Md.
(NASA-TM-101009; A-88212; NAS 1.15:101009) Avail: NTIS HC A03/MF A01 CSCL 22B

The in-flight tests and the operational sequences of the Superfluid Helium On-Orbit Transfer (SHOOT) experiment are outlined. These tests include the transfer of superfluid helium at a variety of rates, the transfer into cold and warm receivers, the operation of an extravehicular activity coupling, and tests of a liquid acquisition device. A variety of different types of instrumentation will be required for these tests. These include pressure sensors and liquid flow meters that must operate in liquid helium, accurate thermometry, two types of quantity gauges, and liquid-vapor sensors. Author

N88-29845*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

TECHNOLOGY REQUIREMENTS FOR AN ORBITING FUEL DEPOT: A NECESSARY ELEMENT OF A SPACE INFRASTRUCTURE

R. M. STUBBS, R. R. CORBAN, and A. J. WILLOUGHBY (Analex Corp., Cleveland, Ohio.) 1988 10 p Presented at the 39th Annual Astronautical Congress of the International AStronautical Federation, Bangalore, India, 8-15 Oct. 1988
(NASA-TM-101370; E-4414; NAS 1.15:101370) Avail: NTIS HC A02/MF A01 CSCL 22B

Advanced planning within NASA has identified several bold space exploration initiatives. The successful implementation of these missions will require a supporting space infrastructure which would include a fuel depot, an orbiting facility to store, transfer and process large quantities of cryogenic fluids. In order to adequately plan the technology development programs required to enable the construction and operation of a fuel depot, a multidisciplinary workshop was convened to assess critical technologies and their state of maturity. Since technology requirements depend strongly on the depot design assumptions, several depot concepts are presented with their effect on criticality ratings. Over 70 depot-related technology areas are addressed. Author

N88-29862# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. for Experimental Fluid Mechanics.

STUDIES ON ROCKET EXHAUST PLUMES AND IMPINGEMENT EFFECTS RELATED TO THE COLUMBUS SPACE STATION PROGRAM: EXECUTIVE SUMMARY

R.-D. BOETTCHER, C. DANKERT, G. DETTLEFF, and H. LEGGE Paris, France ESA Feb. 1988 82 p
(Contract ESA-6829/86-NL-PH(SC))
(DFVLR-IB-222-88-A-12; ESA-CR(P)-2614; ETN-88-93148) Avail: NTIS HC A05/MF A01

Using a plume impingement computer code, possible proximity impingement situations in the Columbus space station were analyzed. Experiments investigated the plume flow immediately downstream of the nozzle. The impingement effects (shear stress and pressure) were measured on a plate inclined with respect to the plume axis up to perpendicular impingement. This situation is considered as typical during rendezvous and docking maneuvers. ESA

N88-29870# R and D Associates, Alexandria, VA. Research Lab.

UNIFIED STUDY OF PLASMA/SURFACE INTERACTIONS FOR SPACE POWER AND PROPULSION Final Report, 15 Jul. 1987 - 29 Feb. 1988

29 Feb. 1988 66 p
(Contract F49620-86-C-0069)
(AD-A195971; AFOSR-88-0600TR) Avail: NTIS HC A04/MF A01 CSCL 20I

High specific impulse, high specific power devices, such as magnetoplasmadynamic arcjets, laser or microwave propulsion channels, and MHD generators, involve the flow of modest temperature (0.5 to 5 eV) partially ionized gases at speeds of 5 to 20 km per sec. The interactions of such flows with solid surfaces containing, channeling or penetrating the flow provides a principal source of concern for the efficiency and lifetime of high specific power systems. The present report describes a basic research effort that examines the plasma/surface interaction experimentally in an arrangement providing diagnostic access usually unavailable in mission-oriented, device-development projects. GRA

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GENERAL

Includes either state-of-the-art or advanced technology which may apply to Large Space Systems and does not fit within the previous categories. Publications of conferences, seminars, and workshops are covered in this area.

A88-24817

HIGH TEMPERATURE COATINGS; PROCEEDINGS OF THE SYMPOSIUM, ORLANDO, FL, OCT. 7-9, 1986

M. KHOBAIB, ED. (Dayton, University, OH) and R. C. KRUTENAT, ED. (Avco Specialty Materials Textron, Lowell, MA) Symposium sponsored by the Metallurgical Society. Warrendale, PA, Metallurgical Society, Inc., 1987, 220 p. No individual items are abstracted in this volume.

This book covers a broad spectrum of topics related to high-temperature coatings. Most of the papers deal with coatings for turbine engine applications, while others address methods for applying coatings and the performance and mechanical behavior of a variety of coatings. The application and performance of thermal barrier coatings is addressed. Coating/substrate interactions and the interfacial stability are also extensively discussed in terms of interdiffusion, microstructural stability, formation of various phases, etc. A novel idea for inspection of the integrity of a coating bond is considered, and the use of chromized coatings for protection against stress corrosion cracking in Space Shuttle applications is examined. C.D.

A88-33426

EASCON '87; PROCEEDINGS OF THE TWENTIETH ANNUAL ELECTRONICS AND AEROSPACE SYSTEMS CONFERENCE, WASHINGTON, DC, OCT. 14-16, 1987

Conference sponsored by IEEE, Armed Forces Communications and Electronics Association, and National Space Club. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, 217 p. For individual items see A88-33427 to A88-33449.

Various papers on space endeavors are presented. The general topics addressed include: U.S. space policy and goals revisited, from earth to orbit and return, science in space, enhanced security from space, and the capabilities of the Space Station. Also discussed are: commercial use of space, general Space Station technology, signal processing technology, leadership in space, and international cooperation and leadership in space. C.D.

A88-33626

ITC/USA/'87; PROCEEDINGS OF THE INTERNATIONAL TELEMETERING CONFERENCE, SAN DIEGO, CA, OCT. 26-29, 1987

Conference sponsored by the International Foundation for Telemetering. Research Triangle Park, NC, Instrument Society of America (ITC Proceedings. Volume 23), 1987, 882 p. For individual items see A88-33627 to A88-33693.

Various papers on telemetering are presented. The general topics considered include: International Space Station telemetry, new technology, recording equipment and systems, Voyager-Neptune telemetry, adaptive signal processing, spacecraft telemetry, data acquisition, PCM telemetry, airborne telemetry, telemetry systems, ballistic application test range instrumentation radars, and unique applications. C.D.

A88-33776

AEROSPACE TESTING SEMINAR, 10TH, LOS ANGELES, CA, MAR. 10-12, 1987, PROCEEDINGS

Seminar sponsored by the Institute of Environmental Sciences and Aerospace Corp. Mount Prospect, IL, Institute of Environmental Sciences, 1987, 270 p. For individual items see A88-33777 to A88-33800.

The conference presents papers on on-orbit experience, aerospace testing effectiveness, test technology issues, requirements, techniques, and facilities. Topics include an analysis of orbital satellite storage, flight problem evaluation for the Space Shuttle Orbiter, on-orbit man/machine interface verification with simulator testing, managing test program risks, refining test effectiveness through cost of quality analysis, single event upset testing at JPL, and testing of satellites after ground storage. Consideration is also given to the thermal testing of space vehicle electronic components, shower water characterization tests, a weightlessness simulation test in the MDAC underwater test facility, and corner acoustic horns in large reverberation chambers. K.K.

A88-33780#

ON-ORBIT, MAN/MACHINE INTERFACE VERIFICATION WITH SIMULATOR TESTING

J. D. HYLTON and R. PULLIAM (Martin Marietta Aerospace Corp., Space Operations Simulator Laboratory, Denver, CO) IN: Aerospace Testing Seminar, 10th, Los Angeles, CA, Mar. 10-12, 1987, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1987, p. 27-33.

The Space Operations Simulator Laboratory at Martin Marietta Denver Aerospace is described in detail. Included in the principal test facilities are the motion base carriage, the large-screen video display, the manipulator development laboratory, the Space Shuttle aft flight deck simulator, target gimbals, and the neutral bouyancy facility. Operational development is discussed with attention given to payload handling, flexible body dynamics, the interactive dynamics of multiple bodies in space, and telesimulation operations. K.K.

A88-34465

COMPUTER APPLICATIONS IN SPACECRAFT DESIGN AND OPERATION

T. K. S. MURTHY, ED. (Computational Mechanics Institute, Southampton, England) and R. E. MUENCH, ED. (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) Berlin and New York, Springer-Verlag, 1987, 196 p. For individual items see A88-34466 to A88-34476.

The papers presented in this volume provide an overview of the use of computer-aided design, manufacture and operation in the aerospace industry. Topics discussed include preliminary design techniques for interplanetary solar-electric propulsion spacecraft, animated computer graphics for spacecraft mission analysis, an integrated computer aided engineering system for space station design, and automatic quality control of meteorological parameters derived from Meteosat imagery. Papers are also presented on expert systems for decision support in military aircraft mission preparation and new tools in support of satellite operation. V.L.

A88-34486

STRUCTURAL MECHANICS OF OPTICAL SYSTEMS II; PROCEEDINGS OF THE MEETING, LOS ANGELES, CA, JAN. 13-15, 1987

ALSON E. HATHEWAY, ED. (Alson E. Hatheway, Inc., Pasadena, CA) Conference sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 748), 1987, 242 p. For individual items see A88-34487 to A88-34508.
(SPIE-748)

The present conference discusses the support structure for the optics of the Multiple Mirror Telescope (MMT), cophasing and coaligning the MMT, the 11.3-m optical telescope of the Columbus project, CAD techniques for a space-based optical system, solid optics for small and complex optical systems, and optical path-length calculations using finite elements. Also discussed are optomechanical analysis strategies, active vibration suppression methods for a large optical system, a conceptual design for the active control of a large optical system, the flexural rigidity characteristics of lightweight mirrors, the structural analysis of a lightweight aluminum foam core mirror, and the response of large optical mirrors to thermal distributions. O.C.

A88-34491

STRUCTURAL INNOVATIONS IN THE COLUMBUS PROJECT - AN 11.3 METER OPTICAL TELESCOPE

WARREN B. DAVISON (Steward Observatory, Tucson, AZ) IN: Structural mechanics of optical systems II; Proceedings of the Meeting, Los Angeles, CA, Jan. 13-15, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 31-37.

The goal of the Steward Observatory's Columbus Project is the construction of an 11.3-m effective aperture telescope by the 500th aniversary of the discovery of America in 1992. The configuration of the telescope is projected to consist of two 8-m diameter F:1 primary mirrors with 14-m center separation; these two mirrors can be supported with a relatively lightweight and simple structure that will facilitate the achievement of high servo performance with modest technology and costs. O.C.

A88-34536

REFLECTIVE OPTICS; PROCEEDINGS OF THE MEETING, LOS ANGELES, CA, JAN. 15, 16, 1987

DIETRICH KORSCH, ED. (Korsch Optics, Inc., Huntsville, AL) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 751), 1987, 157 p. For individual items see A88-34537 to A88-34549.
(SPIE-751)

The present conference discusses prospects for astrophysical space observatories in the next 25 years, a two-mirror three-surface telescope, the structural and thermal feasibility of a 10-m primary mirror space telescope, precision machining implications for optical systems with large off-axis elements, optical wavelength aperture-synthesis interferometry, Space Station lidar measurements with 1.5-m reflective optics, and the performance of phased-array and thinned-aperture optical telescopes. Also discussed are the R-theta diamond-turning system for optical surfaces, diamond-turned Cu mirrors at grazing incidence, the use of visible and IR interferometry in optical testing of large single-point diamond-turned mirrors, the performance of a fast diamond-turned two-mirror colimator, and all-reflecting afocal telescopes. O.C.

A88-34551

COLUMBUS III; PROCEEDINGS OF THE THIRD SYMPOSIUM, CAPRI, ITALY, JUNE 30-JULY 2, 1987

Symposium organized by ESA, BMFT, Ministero per il

best copy available

Coordinamento della Ricerca Scientifica e Tecnologica, and Universita di Napoli; Supported by CNR and Aeritalia S.p.A. Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, 251 p. For individual items see A88-34552 to A88-34575.

The current status of the ESA Columbus program for participation in the International Space Station is surveyed in reviews and reports. Topics addressed include Columbus program definition, Columbus utilization, payloads operation, and international cooperation. Particular attention is given to technological and political factors influencing Columbus, the Columbus Pressurized Modules, the role of Eureca in the Columbus scenario, European earth-observation projects from the Space Station Polar Platform, Columbus and the life sciences, Man-Tended Free Flyer utilization aspects, commercial payload opportunities on Columbus, crew activities, the Japanese Space Station program, and a Canadian view of Space Station utilization issues. T.K.

A88-35051

AEROSPACE CENTURY XXI: SPACE MISSIONS AND POLICY; PROCEEDINGS OF THE THIRTY-THIRD ANNUAL AAS INTERNATIONAL CONFERENCE, BOULDER, CO, OCT. 26-29, 1986

GEORGE W. MORGENTHALER, ED. (Colorado, University, Boulder) and GAYLE L. MAY, ED. Conference sponsored by AAS. San Diego, CA, Univelt, Inc., 1987, 685 p. For individual items see A88-35052 to A88-35092.

The present conference discusses the NASA Space Station's evolution and development status, the Spacehab testbed, Space Station benefits from tether operations, the Columbus resource module for ESA's man-tended free-flier, global climate research with Topex/Poseidon, the Saenger and Hotol reusable launcher concepts, the Tethered Satellite System, mission analysis and phased development of a lunar base, and extraterrestrial infrastructure design projects. Also discussed are the Galileo mission to Jupiter and the Magellan mission to Venus; future international space programs; ESA, German, and Japanese space exploration plans; future applications of space law, and recent developments in U.S. space policy and law; space science and engineering education; and public and professional attitudes to space exploration in the U.S. O.C.

A88-35093

AEROSPACE CENTURY XXI: SPACE FLIGHT TECHNOLOGIES; PROCEEDINGS OF THE THIRTY-THIRD ANNUAL AAS INTERNATIONAL CONFERENCE, BOULDER, CO, OCT. 26-29, 1986

GEORGE W. MORGENTHALER, ED. and W. KENT TOBISKA, ED. (Colorado, University, Boulder) Conference sponsored by AAS. San Diego, CA, Univelt, Inc., 1987, 606 p. For individual items see A88-35094 to A88-35122.

Among the topics discussed are advanced electric propulsion for interplanetary missions, NASA Space Station propulsion, nuclear reactor-based space power systems, electrodynamic tethers for space power and thrust generation, exotic 21st-century spacecraft propulsion, control systems for autonomous operation of the Magellan spacecraft, spacecraft thermal management systems, aerobraking maneuver-related problems, and advanced heavy lift launch vehicles. Also discussed are a space telerobot concept, space-based robotic assembly and maintenance, advanced Al alloys and Al/polymer laminates for aerospace structures, lubrication for space environments, distributed and concurrent computation methods for space structures, and 32-GHz deep space communications. O.C.

A88-35526

RECENT TRENDS IN AEROELASTICITY, STRUCTURES, AND STRUCTURAL DYNAMICS; PROCEEDINGS OF THE R. L. BISPLINGHOFF MEMORIAL SYMPOSIUM, UNIVERSITY OF FLORIDA, GAINESVILLE, FL, FEB. 6, 7, 1986

PRABHAT HAJELA, ED. (Florida, University, Gainesville) Symposium sponsored by NSF, USAF, and MIT;. Gainesville, FL, University Presses of Florida, 1987, 424 p. For individual items see A88-35527 to A88-35547.
(Contract NSF ECE-86-02170)

The papers contained in this volume provide an overview of the state of the art in the field of aeroelasticity and aeronautical structures, including surveys of well-developed fields of study and new contributions in emerging areas of technology. The subject areas covered include fixed and rotary wing aeroelasticity, aeroelastic considerations in rotating machinery; aeroelastic problems in bridge design; structural analysis and structural dynamics in aerospace applications; aeroservoelastic considerations; and the emerging discipline of optimal structural design. Papers are presented on the whirl flutter of swept tip propfans; aeroelasticity of very light aircraft; structural stability in turbulent flow; and structural tailoring of aircraft performance. V.L.

A88-36123

SECULAR EFFECTS IN THE TRANSLATIONAL-ROTATIONAL MOTION OF AN ORBITAL STATION WITH ARTIFICIAL GRAVITY [VEKOVYE EFFEKTY V POSTUPATEL'NO-VRASHCHATEL'NOM DVIZHENII ORBITAL'NOI STANTSII, OBLADAIUSHCHEI ISKUSSTVENNOI TIAZHEST'IU]

D. Z. KOENOV (Tadzhikskii Gosudarstvennyi Universitet, Dushanbe, Tadzhik SSR) Akademiia Nauk Tadzhikskoi SSR, Doklady (ISSN 0002-3469), Vol. 30, no. 7, 1987, p. 417-420. In Russian.

Attention is given to an orbital station which has the form of two spheres of the same radius connected with a long tether; the spheres rotate about an axis passing through their common center of mass. Formulas are derived which show that the form of this station has a substantial effect on the translational motion of the station around the earth. The form of the station does not have any secular effect on the rotational motion of the station about the nutation axis. B.J.

A88-36144

OPTIMAL RENDEZVOUS IN A GRAVITATIONAL FIELD WITH LIMITED OBSERVATIONS [OB OPTIMAL'NOI PARITETNOI VSTRECHE V GRAVITATSIONNOM POLE PRI OGRANICHENNYKH NABLIUDENIIAKH]

V. S. NOVOSELOV Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1988, p. 67-71. In Russian.

A solution is presented to the model problem of optimizing the rendezvous of space stations moving in coplanar circular orbits. The solution allows for initial position errors and for errors in impulse processing. The stations have equal characteristic velocities, which are minimized together with the duration of angular position observations. V.L.

A88-37239

NATIONAL SPACE ENGINEERING SYMPOSIUM, 3RD, CANBERRA, AUSTRALIA, JUNE 30-JULY 2, 1987, PREPRINTS OF PAPERS

Symposium sponsored by the Institution of Engineers of Australia, Australian Space Board, and CSIRO. Barton, Australia/Brookfield, VT, Institution of Engineers/Brookfield Publishing Co. (National Conference Publication, No. 87/8), 1987, 287 p. For individual items see A88-37240 to A88-37282.

The present conference on space engineering considers Aussat's satellite operations, the HOTOL space transport, Australian thoughts on the new reusable launch vehicles, a land-mobile satellite service for Australia, the Australian ERS-1 program, an Australian geosynchronous satellite radio beacon, Europe's 'Esrange', present and future defense satellite communications between the U.S. and Australia, Aussat in-orbit anomalies' correlation with the GEO radiation environment, the Lyman UV space telescope, and low cost exploration of the Sarsat-COSPAS system. Also discussed are the Australian space industry, an international spaceport for Australia, the Endeavour Program, space applications of muon-catalyzed fusion, the

Australian Amateur Radio Satellite, the development status of the Australian Telescope, and Australian availability of oxygen and hydrogen fuel gases. O.C.

A88-37273#

PROJECT ENDEAVOUR - CANNISTER 2 SUPPORT STRUCTURE

J. A. S. RAJU (Hawker de Havilland Australia Pty., Ltd., Bankstown) IN: National Space Engineering Symposium, 3rd, Canberra, Australia, June 30-July 2, 1987, Preprints of Papers. Barton, Australia/Brookfield, VT, Institution of Engineers/Brookfield Publishing Co., 1987, p. 203-209.

The Canninster 2 element of the 'two-can' Project Endeavour Get-Away Special (GAS) is connected to the telescope-containing first can by a tether and houses the battery, two VCRs, a signal-conversion unit, and a relay-switching unit. The Cannister 2 support structure is designed to locate, support, and thermally insulate these units within the GAS can. The structure's sidewalls are the major structural members, and incorporate integral legs that straddle the battery and are accommodated in the corner recesses of the battery profile. O.C.

A88-38077

RADIO ASTRONOMY FROM SPACE; PROCEEDINGS OF THE WORKSHOP, GREEN BANK, WV, SEPT. 30-OCT. 2, 1986

KURT W. WEILER, ED. (U.S. Navy, Naval Research Laboratory, Washington, DC) Workshop sponsored by the National Radio Astronomy Observatory. Charlottesville, VA, National Radio Astronomy Observatory (NRAO Workshop, No. 18), 1987, 341 p. For individual items see A88-38078 to A88-38109.

The scientific aims and technological implementation of planned and proposed space radio observatories are examined in reviews and reports. Observations at mm and submm, cm, dkm, and hm wavelengths are considered, and particular attention is given to astrophysical problems requiring space-based observations; radio astronomy from the moon; coordination of ground, airborne, balloon-borne, and space-based mm and submm astronomy; microwave-background observations at 15-90 GHz, the Large Deployable Reflector, the Space Station mm-wave facility, the use of TDRSS as an orbiting VLBI observatory, and interstellar scattering and resolution limitations. Also discussed are Quasat, Astro-Array, VLBA, solar-system radio astronomy at low frequencies, radio emission from coronal and interplanetary shocks, and Tasmanian LF Galactic background surveys. T.K.

A88-38097

SELF-CORRECTION OF TELESCOPE SURFACE ERRORS USING A CORRELATING FOCAL PLANE ARRAY

T. J. CORNWELL and P. J. NAPIER (National Radio Astronomy Observatory, Socorro NM) IN: Radio astronomy from space; Proceedings of the Workshop, Green Bank, WV, Sept. 30-Oct. 2, 1986. Charlottesville, VA, National Radio Astronomy Observatory, 1987, p. 215-219. refs

The effects on the performance of a large radio telescope of aberrations such as reflector surface errors, defocussing, coma and pointing errors can be removed if the telesocpe is equipped with an array feed in its focal plane. If the cross correlations between all possible pairs of array elements are measured, then aberration-free images of radio sources can be obtained. Because of the great cost of building very precise large structures in space, in the future this concept may offer the possibility of a more economical design for a large, high frequency, spaceborn radio telescope. Author

A88-38304

30 YEARS OF PROGRESS IN SPACE; PROCEEDINGS OF THE THIRTY-EIGHTH INTERNATIONAL ASTRONAUTICAL CONGRESS, BRIGHTON, ENGLAND, OCT. 10-17, 1987

L. G. NAPOLITANO, ED. (Napoli, Universita, Naples, Italy) Congress sponsored by IAF. Acta Astronautica (ISSN 0094-5765), vol. 18, 1988, 398 p. For individual items see A88-38305 to A88-38307.

The present conference gives attention to orbital maneuvering vehicle capabilities, the impact of launch vehicle constraints on NASA Space Station design and operations, the Office of Space Flight satellite servicing program plan, an end-to-end analysis and demonstration of telerobotics and orbital laboratories, a development scenario for the H-II orbiting spaceplane HOPE, navigation of the Hermes spaceplane, and a postoperational disposal strategy for a space nuclear reactor. Also discussed are combined cycle propulsion systems for hypersonic flight, hybrid boosters for future launch vehicles, nuclear rocket safety, the development history of NASA tracking and data acquisition networks, the Indian remote sensing program, remote mineralogical and vegetation mapping using imaging spectrometry, and solar system colonization and interstellar migration. O.C.

A88-38826

'GLAZAR' - AN ORBITAL ULTRAVIOLET TELESCOPE ['GLAZAR' - ORBITAL'NYI UL'TRAFIOLETOVYI TELESKOP]

G. M. TOVMASIAN, IU. M. KHODZHAIANTS, M. N. KRMOIAN, A. L. KASHIN, A. Z. ZAKHARIAN (Biurakanskaia Astrofizicheskaia Observatoriia, Byurakan, Armenian SSR; Geneve, Observatoire, Sauverny, Switzerland) et al. Pis'ma v Astronomicheskii Zhurnal (ISSN 0320-0108), vol. 14, April 1988, p. 291-295. In Russian.

The ultraviolet telescope Glazar situated on the Quant astrophysical module of the Mir space station is described. The parameters of the telescope and its star trackers are presented. The scientific program of this space experiment is outlined. Star images obtained with the telescope's detached tracking system after 50 sec of exposure are given. K.K.

A88-39050

SPACE: COUNTDOWN TO THE FUTURE; NATIONAL SPACE SYMPOSIUM, 3RD, COLORADO SPRINGS, CO, JAN. 20-23, 1987, REPORT

STEVEN D. MITCHELL, ED. Symposium sponsored by the United States Space Foundation, Aerospace Education Foundation, Boeing Aerospace Co. et al. Colorado Springs, CO, United States Space Foundation, 1987, 314 p. No individual items are abstracted in this volume.

Technological and political aspects of the U.S. civilian and military space programs are examined in individual presentations and panel discussions reflecting a wide spectrum of viewpoints. Topics addressed include the current status of SDI, space goals and strategy, launch options and the new emphasis on ELVs, space commercialization, military R&D options, DOD programs, space militarization, the U.S. space program in the year 2000, space law and policy, and space education. Also considered are the current space activities of ESA, the FRG, Japan, China, France, the UK, and Canada. T.K.

A88-39424#

REAL-TIME SYSTEMS FOR SPACE APPLICATIONS

ULRICH SCHWAN and HANS-JUERGEN HERPEL Dornier-Post (English Edition) (ISSN 0012-5563), no. 2, 1988, p. 63-65.

A real-time operating system for spacecraft management, in which parallel operation is achieved through the distribution of different tasks to autonomous computers or the assignment of the processing or memory resource of a given computer to different tasks, is a service program which resolves the problem of simultaneity by acting between hardware and application software. Attention is here given to the iRMX86 real-time operating system's application to CO2-removal control in the Columbus space station life-support system, as well as other C programming language-based real-time spacecraft operations systems. O.C.

A88-40251

1987 SEM SPRING CONFERENCE ON EXPERIMENTAL MECHANICS, HOUSTON, TX, JUNE 14-19, 1987, PROCEEDINGS

Conference sponsored by SEM. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, 981 p. For individual items see A88-40252 to A88-40301.

The papers presented in this volume provide an overview of current research in the field of experimental mechanics. Topics discussed include composites, photoelasticity, optical methods in experimental mechanics, fracture, and modal testing and analysis. Other topics include identification of large structures, gaskets and bolted assemblies, strain gage applications, hybrid techniques in fracture and stress analysis, and wave propagation studies using optical techniques. V.L.

A88-41276* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

VISIONS OF TOMORROW: A FOCUS ON NATIONAL SPACE TRANSPORTATION ISSUES; PROCEEDINGS OF THE TWENTY-FIFTH GODDARD MEMORIAL SYMPOSIUM, GREENBELT, MD, MAR. 18-20, 1987

GERALD A. SOFFEN, ED. (NASA, Goddard Space Flight Center, Greenbelt, MD) Symposium sponsored by AIAA, AAS, National Space Club, et al. San Diego, CA, Univelt, Inc. (Science and Technology Series. Volume 69), 1987, 338 p. For individual items see A88-41277 to A88-41290.

The present conference on U.S. space transportation systems development discusses opportunities for aerospace students in prospective military, civil, industrial, and scientific programs, current strategic conceptualization and program planning for future U.S. space transportation, the DOD space transportation plan, NASA space transportation plans, medium launch vehicle and commercial space launch services, the capabilities and availability of foreign launch vehicles, and the role of commercial space launch systems. Also discussed are available upper stage systems, future space transportation needs for space science and applications, the trajectory analysis of a low lift/drag-aeroassisted orbit transfer vehicle, possible replacements for the Space Shuttle, LEO to GEO with combined electric/beamed-microwave power from earth, the National Aerospace Plane, laser propulsion to earth orbit, and a performance analysis for a laser-powered SSTO vehicle. O.C.

A88-41285

TRAJECTORY ANALYSIS OF A LOW LIFT/DRAG AEROASSISTED ORBIT TRANSFER VEHICLE

ROBERT D. BRAUN (Pennsylvania State University, University Park) IN: Visions of tomorrow: A focus on national space transportation issues; Proceedings of the Twenty-fifth Goddard Memorial Symposium, Greenbelt, MD, Mar. 18-20, 1987. San Diego, CA, Univelt, Inc., 1987, p. 163-174. refs
(AAS PAPER 87-123)

This paper presents the results of an undergraduate thesis pertaining to four significant aspects of an aeroassisted orbit transfer vehicle trajectory analysis. The orbital trajectories were simulated by utilizing the computer optimization program POST at the NASA-Langley Research Center. This optimization was based on the spacecraft's known properties and constraints, in particular the vehicle's heating-rate restriction. Through this analysis, the influence of both aerodynamic and astrodynamic parameters on the vehicle's flight path are determined. Additionally, various means of producing the required orbital transfer energy decrement, as well as the tradeoff between the spacecraft's time-of-flight and propellant expended, are studied. Author

A88-41882

ADVANCED COMPOSITES III: EXPANDING THE TECHNOLOGY; PROCEEDINGS OF THE THIRD ANNUAL CONFERENCE, DETROIT, MI, SEPT. 15-17, 1987

Conference sponsored by ASM International, Engineering Society of Detroit, Society of Plastics Engineers. Metals Park, OH, ASM International, 1987, 408 p. For individual items see A88-41883 to A88-41895.

The present conference discusses topics in the design features and methods, manufacturing processes, secondary fabrication techniques, and materials science aspects of advanced composites. Attention is given to composite structural armor for ground combat vehicles, composite structures for automotive energy management, CAD/CAM of braided preforms for advanced composites, composite automobile bumper beams, preforming for structural applications, the three-dimensional braiding of thermoplastic composite preforms, and recent advancements in tooling technology. Also discussed are instrument-grade MMCs for imaging IR guidance systems, automated tape layup of a vertical stabilizer fin, the mechanical properties of thermoplastic matrix composites, surface chemistry and adhesion of SMCs, fiber-matrix bonding, and hybrid yarns for high performance thermoplastic composites. O.C.

A88-42539* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

PERFORMANCE CONSIDERATIONS FOR THE ASTROMETRIC TELESCOPE FACILITY ON THE PHASE I SPACE STATION

KENJI NISHIOKA, ALFRED C. MASCY, CHARLES K. SOBECK, JOEL SPERANS (NASA, Ames Research Center, Moffett Field, CA), and GEORGE D. GATEWOOD (Pittsburgh, University, PA) IN: Optoelectronic technologies for remote sensing from space; Proceedings of the Meeting, Cannes, France, Nov. 19, 20, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 88-96. Previously announced in STAR as N88-14898. refs

The Astrometric Telescope Facility (ATF) is an optical telescope facility of extreme astrometric precision whose principal scientific purpose is the detection and study of planetary systems about nearby stars. With the recent change in the space station program to two phases, the suitability of initial operations from the phase 1 station need to be evaluated. This paper presents the results of such an evaluation for the Astrometric Telescope Facility. Author

A88-42547

SPACE STRUCTURES, POWER, AND POWER CONDITIONING; PROCEEDINGS OF THE MEETING, LOS ANGELES, CA, JAN. 11-13, 1988

RAYMOND F. ASKEW, ED. (Auburn University, AL) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 871), 1988, 368 p. For individual items see A88-42548 to A88-42590.
(SPIE-871)

Various papers on space structures, power, and power conditioning are presented. Among the topics discussed are: heterogeneous gas core reaction for space nuclear power, pulsed gas core reactor for burst power, fundamental considerations of gas core reactor systems, oscillating thermionic conversion for high-density space power, thermoelectromagnetic pumps for space nuclear power systems, lightweight electrochemical converter for space power applications, ballistic acceleration by superheated hydrogen, laser-induced current switching in gaseous discharge, electron-beam-controlled semiconductor switches, laser-controlled semiconductor closing and opening switch. Also addressed are: semiconductor-metal eutectic composites for high-power switching, optical probes for the characterization of surface breakdown, 40 kV/20 kA pseudospark switch for laser applications, insulation direction for high-power space systems, state space simulation of spacecraft power systems, structural vibration of space power station systems, minimum-time control of large space structures, novel fusion reaction for space power and propulsion, repetition rate system evaluations, cryogenic silicon photoconductive switches for high-power lasers, multilevel diamondlike carbon capacitor structure, surface breakdown of prestressed insulators, C-Mo and C-Zr alloys for space power systems, magnetic insulation for the space environment. C.D.

A88-42829

INTERNATIONAL SYMPOSIUM ON THERMAL PROBLEMS IN SPACE-BASED SYSTEMS, BOSTON, MA, DEC. 13-18, 1987, PROCEEDINGS

FLAVIO DOBRAN, ED. (New York University, NY) and MURRAY IMBER, ED. (New York, Polytechnic University, Brooklyn) Symposium sponsored by ASME and SDIO. New York, American Society of Mechanical Engineers, 1987, 143 p. For individual items see A88-42830 to A88-42843.

The present conference discusses fluid mechanics and heat transfer problems pertaining to space-based systems. Particular attention is given to super heat pipe design considerations for application to space-based systems, an experimental investigation of low gravity two-phase flow behavior, and the response of a double wall artery heat pipe to pulsed heat loads. Also considered are the Marangoni convection on a germanium float zone, gas liquid flow at microgravity conditions, and ascent and reentry heat rejection concepts for the Hermes space plane. Other topics include conjugating binary solutions for spacecraft thermal control, the application of two-phase thermal transport systems to space platforms, and two-dimensional thermal conduction effects in high-power CW laser target plates. R.R.

A88-42909*# George Washington Univ., Hampton, VA.
SYSTEMS ANALYSIS OF A LOW-ACCELERATION RESEARCH FACILITY
GARY L. MARTIN (George Washington University, Hampton, VA), MELVIN J. FEREBEE, JR., and ROBERT L. WRIGHT (NASA, Langley Research Center, Hampton, VA) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 13 p. refs
(AIAA PAPER 88-3512)

The Low-Acceleration Research Facility (LARF), an unmanned free-flier that is boosted from low-earth orbit to a desired altitude using an orbital transfer vehicle is discussed. Design techniques used to minimize acceleration-causing disturbances and to create an ultra-quiet workshop are discussed, focusing on residual acceleration induced by the environment, the spacecraft and experiments. The selection and integration of critical subsystems, such as electrical power and thermal control, that enable the LARF to accomodate sub-microgravity levels for extended periods of time are presented, including a discussion of the Low-Acceleration Module, which will supply the payload with 25.0 kW of power, and up to 11.8 kW in the low-power mode. Also, the data management, communications, guidance, navigation and control, and structural features of supporting subsystems are examined. R.B.

A88-42910*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
MULTIMISSION MODULAR SPACECRAFT (MMS)
EDWARD FALKENHAYN, JR. (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 6 p.
(AIAA PAPER 88-3513)

This paper discusses the design requirements for the low-cost standard spacecraft development which has come to be known as the Multimission Modular Spacecraft (MMS). The paper presents the wide range of launch configurations of the MMS users, the population of programs using the MMS, and the cost effectiveness of the MMS concept. The paper addresses the in-orbit serviceability of the design as demonstrated by the successful SMM repair, and the recent selection of MMS for the Explorer Platform, which features in-orbit payload exchanges. Author

A88-42912*# Flight Mechanics and Control, Inc., Hampton, VA.
ADVANCED SATELLITE SERVICING FACILITY STUDIES
GARRY D. QUALLS (Flight Mechanics and Control, Inc., Hampton, VA) and MELVIN J. FEREBEE, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 12 p. refs
(AIAA PAPER 88-4200)

A NASA-sponsored systems analysis designed to identify and recommend advanced subsystems and technologies specifically for a manned Sun-synchronous platform for satellite management is discussed. An overview of system design, manned and unmanned servicing facilities, and representative mission scenarios are given. Mission areas discussed include facility based satellite assembly, checkout, deployment, refueling, repair, and systems upgrade. The ferrying of materials and consumables to and from manufacturing platforms, deorbit, removal, repositioning, or salvage of satellites and debris, and crew rescue of any other manned vehicles are also examined. Impacted subsytems discussed include guidance navigation and control, propulsion, data management, power, thermal control, structures, life support, and radiation management. In addition, technology issues which would have significant impacts on the system design are discussed. R.B.

A88-42933*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPACE VEHICLE APPROACH VELOCITY JUDGMENTS UNDER SIMULATED VISUAL SPACE CONDITIONS
RICHARD F. HAINES (NASA, Ames Research Center, Moffett Field, CA) IN: International Symposium on Aviation Psychology, 4th, Columbus, OH, Apr. 27-30, 1987, Proceedings. Columbus, OH, Ohio State University, 1987, p. 44-50. Previously announced in STAR as N88-19094. refs

Thirty-five volunteers responded when they first perceived an increase in apparent size of a collimated, 2-D image of an Orbiter vehicle. The test variables of interest included the presence of a fixed angular reticle within the field of view (FOV); three initial Orbiter distances; three constant Orbiter approach velocities corresponding to 1.6, 0.8, and 0.4 percent of the initial distance per second; and two background starfield velocities. It was found that: (1) at each initial range, increasing approach velocity led to a larger distance between the eye and Orbiter image at threshold; (2) including the fixed reticle in the FOV produced a smaller distance between the eye and Orbiter image at threshold; and (3) increasing background star velocity during this judgment led to a smaller distance between the eye and Orbiter image at threshold. The last two findings suggest that other detail within the FOV may compete for available attention which otherwise would be available for judging image expansion; thus, the target has to approach the observer nearer than otherwise if these details were present. These findings are discussed in relation to previous research and possible underlying mechanisms. Author

A88-43176
FIBER OPTIC SYSTEMS FOR MOBILE PLATFORMS; PROCEEDINGS OF THE MEETING, SAN DIEGO, CA, AUG. 20, 21, 1987
NORRIS LEWIS, ED. and EMERY L. MOORE, ED. (Litton Industries, Beverly Hills, CA) SPIE-sponsored research. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 840), 1987, 181 p. For individual items see A88-43177 to A88-43187.
(SPIE-840)

Various papers on fiber optic systems for mobile platforms are presented, including automotive, shipboard, aircraft, spacecraft, launch, and missile applications. Individual topics addressed include: new plastic optical fiber with polycarbonate core and fluorescence-doped fiber for high-temperature use, lost-cost 1 x 2 fiber optic coupler using plastic fiber, microminiature fiber optic accelerometer, fiber optic circuits for aircraft engine controls, and linear fiber optic data bus for aircraft applications. Also discussed are: comparison of various architectures of microwave fiber optic links - a system-level analysis, rf characteristics of wideband optical link for interconnection of microwave rf subsystems for airborne communications satellite terminals, cable and connector design issues for mobile platform applications, role of fiber optics on commercial aircraft, FO-LAN-based intelligent sensor testbed for propulsion and avionics module, and optical technology for spacecraft antennas. C.D.

A88-43247
SCIENTIFIC AND ECONOMY-ORIENTED SPACE SYSTEMS /REVISED EDITION/
V. S. AVDUEVSKII and G. R. USPENSKII (Narodnokhoziaistvennye i nauchnye kosmicheskie kompleksy, Moscow, Izdatel'stvo Mashinostroenie, 1985) Moscow, MIR Publishers, 1988, 440 p. Translation. Previously cited in issue 13, p. 1803, Accession no. A86-29843. refs

A88-43333
SYSTEM EFFECTIVENESS-A KEY TO ASSURANCE
PAUL DICK (General Electric Co., Astro-Space Div., Philadelphia,

PA) IN: Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 77-85.

The increasing demands for long life and reliability performance in space for communication satellites has focused increased attention on those critical parts, materials, processes, subassemblies, assemblies, and products whose individual performance is essential to the success of the mission. Various case histories, problems, concerns, and uncertainties that arose during the design, manufacture, test, and acceptance of critical items on several communications satellite programs are reported. It is shown how they were resolved by system effectiveness activities. Subsequent corrective action taken is discussed. I.E.

A88-43951

SPACE MANUFACTURING 6 - NONTERRESTRIAL RESOURCES, BIOSCIENCES, AND SPACE ENGINEERING; PROCEEDINGS OF THE EIGHTH PRINCETON/AIAA/SSI CONFERENCE, PRINCETON, NJ, MAY 6-9, 1987

BARBARA FAUGHNAN, ED. and GREGG E. MARYNIAK, ED. Conference sponsored by AIAA and Space Studies Institute. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, 412 p. For individual items see A88-43952 to A88-43972, A88-43974 to A88-43993.

The present conference on the colonization and economic exploitation of space considers topics in biomedics, space transportation, nonterrestrial resources, the use of launch vehicle external tanks as structural bases for space habitats, international law and economics considerations, the technological bases of space manufacturing plant and solar power satellites, artificial biospheres and closed-cycle life-support systems, and the social aspects of spaceflight. Attention is given to bone and muscle response to long-duration space missions, the energetics of closed biological life-support systems, a LEO space farm, crew factors in NASA Space Station design, the economic impact of extraterrestrial medicine, beamed energy for spacecraft propulsion, the electric rail rocket, and the extraction of silicon, aluminum, and oxygen from lunar ore. O.C.

A88-43966#

A JOB FOR SPACE MANUFACTURING

J. W. STRYKER IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 158-163.

Space habitation will create a need for a general purpose repair, rebuilding, and manufacturing facility. The self-contained 'job shop' concept fits this need. A single, multi-purpose machine tool combined with a large variety of accessories is proposed. This uses existing and proven technology, requiring only some minor adaption for work in space. Also, there is a large experience base of job shop techniques which can be drawn upon. A job shop can modify tools and equipment already in orbit. It can perform production manufacturing for many of the sub-components needed in the construction of additional habitats. This adaptability also provides valuable capacity when Shuttle or other transportation links may experience delays. It creates a 'bootstrapping' capability which can significantly lower manufacturing costs in space. This paper presents specific design aspects which can help achieve this goal. Author

A88-43967#

SPACE STATION TOOL KIT

WILLIAM LEWIS (Washington, University, Seattle), DWIGHT WAHLBERG (California, University, La Jolla), and ARCHIE BREEDEN IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 167-170.

Since a module-replacement strategy cannot furnish complete coverage of all possible system failures on the NASA Space Station, an attempt is presently made to identify those tools that may be most efficiently and with the minimum possible mass employed to undertake component-level repairs and maintenance improvisation. This speculative 'tool kit' is intended to demonstrate the possibility of very general purpose tools, as well as to adumbrate the character of prospective on-orbit repairs. Electrical, electronic, piping, structural, and informational components would be encompassed by the kit. O.C.

A88-44001

ADVANCED TOPICS IN MANUFACTURING TECHNOLOGY: PRODUCT DESIGN, BIOENGINEERING; PROCEEDINGS OF THE SYMPOSIUM, ASME WINTER ANNUAL MEETING, BOSTON, MA, DEC. 13-18, 1987

PHILIP H. FRANCIS, ED. Symposium sponsored by ASME. New York, American Society of Mechnical Engineers, 1987, 106 p. For individual items see A88-44002 to A88-44007.

Papers on manufacturing technology related to engineering are presented in the fields of product design, bioengineering, and space commercialization. Aspects of product design and bioengineering covered included design issues in mechanical tolerance analysis, computer-aided product design for economical manufacture, gestural control of industrial robots applied to surgical instrument positioning, voice control of manufacturing systems, eye tracking control of robotic systems, and man-machine interaction. Topics in space commercialization include an overview of space commercialization by an aerospace corporation, commercial development of space, power system technology, welding in space, remote sensing technology and applications, commercial materials processing in the space station, and microgravity science and applications projects and payloads. R.B.

A88-44527#

COST EFFECTIVENESS OF ON-ORBIT SERVICING FOR LARGE CONSTELLATIONS

WILLIAM ROBERTSON, JACK SLINEY, and JOEL LUNA (Dynamics Research Corp., Systems Div., Arlington, VA) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 22 p. refs

(AIAA PAPER 88-3519)

This paper examines the cost effectiveness of on-orbit support for large constellations with the use of a space-based support infrastructure, a concept whereby space assets are serviced and repaired in their operational orbits using a space-based support platform and an appropriate servicing subsystem, such as an OMV. The characteristics of a viable on-orbit maintenance and servicing concept are considered together with the systems/subsystems that are necessary to perform on-orbit maintenance and servicing. The cost analyses performed are structured to maintain consistency and balance between the competing support alternatives, using the launch-to-replace concept as a baseline against which the on-orbit support alternatives are compared. I.S.

A88-44695*# Martin Marietta Corp., Denver, CO.

ORBITAL SPACECRAFT CONSUMABLES RESUPPLY

SAM M. DOMINICK, RALPH N. EBERHARDT, and THOMAS R. TRACEY (Martin Marietta Corp., Denver, CO) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. Research supported by Martin Marietta Corp. refs

(Contract NAS9-17585)

(AIAA PAPER 88-2922)

The capability to replenish spacecraft, satellites, and laboratories on-orbit with consumable fluids provides significant increases in their cost and operational effectiveness. Tanker systems to perform on-orbit fluid resupply must be flexible enough to operate from the Space Transportation System (STS), Space Station, or the Orbital Maneuvering Vehicle (OMV), and to accommodate launch from both the Shuttle and Expendable Launch Vehicles (ELV's). Resupply systems for storable monopropellant hydrazine and bipropellants, and water have been developed. These studies have concluded that designing tankers capable of launch on both the Shuttle and ELV's was feasible and desirable. Design modifications and interfaces for an ELV launch of the tanker systems were identified. Additionally, it was determined that modularization of the tanker subsystems was necessary to provide the most versatile tanker and most efficient approach for use at the Space Station. The need to develop an automatic umbilical mating mechanism, capable of performing both docking and coupler mating functions was identified. Preliminary requirements for such a mechanism were defined. The study resulted in a modular tanker capable of resupplying monopropellants, bipropellants, and water with a single design. Author

A88-45034

DATA MANAGEMENT FOR LARGE SPACE SYSTEMS

C. J. SHELFORD (British Aerospace, PLC, Space and Communications Div., Stevenage, England) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 41, July 1988, p. 307-309.

This paper examines the major tasks and features of an on-board data management system (DMS) being currently designed for large space systems. The special features of this DMS will include high damage tolerance, ability to provide communications between a large number of dissimilar data sources and to transfer data at high speed, high flexibility in terms of system operation and growth, and easy maintenance and servicing. A major element of the DMS is the data network which will be implemented as a 'local area network' and which will transport data between users at rates compatible with users' requirements. The network interfaces will be made simple, reliable, and effective and of a complexity consistent with the mission objectives. I.S.

A88-46070

SOVIET SPACE ACHIEVEMENTS IN 1985 ACCORDING TO PRESS MATERIALS [OSVOENIE KOSMICHESKOGO PROSTRANSTVA V SSSR, 1985: PO MATERIALAM PECHATI]

R. Z. SAGDEEV, ED. Moscow, Izdatel'stvo Nauka, 1987, 200 p. In Russian. No individual items are abstracted in this volume.

The present work is a compilation of press materials (e.g., TASS reports and newspaper articles) reflecting Soviet achievements in space in 1985. Particular consideration is given to space-flight planning, manned flights, and international cooperation in space. B.J.

A88-46776

ACTIVE EXPERIMENTS; PROCEEDINGS OF SYMPOSIUM 1 OF THE TWENTY-SIXTH COSPAR PLENARY MEETING, TOULOUSE, FRANCE, JUNE 30-JULY 11, 1986

G. HAERENDEL, ED. (Max-Planck-Institut fuer Physik und Astrophysik, Garching, Federal Republic of Germany) and M. MENDILLO, ED. (Boston University, MA) Symposium and Meeting sponsored by COSPAR, URSI, and IAGA. Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, 301 p. For individual items see A88-46777 to A88-46815.

Recent investigations of the thermosphere, ionosphere, magnetosphere, and solar wind by means of active experiments are examined in reviews and reports. Topics discussed include plasma and neutral-gas injections, electron- and ion-beam injections, vehicle-environment interactions, and active wave experiments. Particular attention is given to the results of the AMPTE experiments, computer simulations of ion-beam propagation, the Charge-2 tethered rocket experiment, opportunities for active wave experiments on the Space Station, and the physical processes involved in ionospheric-heating experiments. T.K.

A88-49026

PERSPECTIVES OF SOVIET COSMONAUTICS. I [PERSPEKTIVEN DER SOWJETISCHEN KOSMONAUTIK. I]

RENE LORENZI (Zuerich, Eidgenoessische Technische Hochschule, Zurich, Switzerland) Astronautik (ISSN 0004-6221), vol. 25, Apr.-June 1988, p. 41, 42. In German. refs

Recent Soviet manned space activities are briefly reviewed. The present state of orbital stations is addressed, including the state of the art in their construction. Soviet industrial production in space is examined, and the role of energy supply and transport systems in present Soviet manned space activities is addressed. C.D.

A88-50160

AIAA GUIDANCE, NAVIGATION AND CONTROL CONFERENCE, MINNEAPOLIS, MN, AUG. 15-17, 1988, TECHNICAL PAPERS. PARTS 1 & 2

Conference sponsored by AIAA. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. Pt. 1, 590 p.; pt. 2, 582 p. For individual items see A88-50161 to A88-50279.

Theoretical and applications aspects of aircraft and spacecraft guidance, control, and navigation are examined in reviews and reports of recent investigations. Topics addressed include the optimal nonlinear regulator problem, nonlinear control of a twin-lift helicopter configuration, pole/zero cancellation in flexible space structures, modeling of noncollocated structural control systems, maximum-terminal-velocity descent to a point, test results on spaceborne laser radars, two-controller designs for decentralized systems, and reduction of missile navigation errors by roll programming. Consideration is given to eigenspace methods for symmetric flutter suppression, a quaternion feedback regulator for spacecraft eigenaxis rotations, thrust vectoring and poststall capability in air combat, guidance and control for cooperative tether-mediated orbital rendezvous, a high-accuracy CCD sun sensor, and pilot decisionmaking during low-altitude wind-shear encounters. T.K.

A88-50352

AIAA/AAS ASTRODYNAMICS CONFERENCE, MINNEAPOLIS, MN, AUG. 15-17, 1988, TECHNICAL PAPERS

Conference sponsored by AIAA and AAS. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, 760 p. For individual items see A88-50353 to A88-50407, A88-50409 to A88-50439.

Papers are presented on precise orbit computations of Lageos, an ideal reference frame for perturbed orbital motion, the celestial mechanics of gravity assist, and a slew maneuver experiment of mission function control. Also considered are an error analysis for a Mars landing, a collision matrix for LEO satellites, Galilean satellite ephemeris improvement using Galileo tour encounter information, and low-thrust power-limited transfer for a pole squatter. Other topics include navigating Neptune, long-term revisit coverage using multisatellite constellations, optimal payload lofting with tethers, and double lunar swingby trajectory design. Papers are also presented on explicit guidance along an optimal space curve, analytical models for relative motion under constant thrust, and a GPS constellation buildup plan. R.R.

A88-50590#

AEROASSISTED TRANSFER BETWEEN ELLIPTICAL ORBITS USING LIFT CONTROL

DAVID MISHNE (Rafael Armament Development Authority, Haifa, Israel), JOSEF SHINAR (Technion - Israel Institute of Technology, Haifa), and NAHUM MELAMED IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 134-141. refs
(AIAA PAPER 88-4346)

A transfer between two elliptical orbits, using an atmospheric passage, is considered. In the atmosphere, the lift of the spacecraft is controlled to change the line of apsides of the orbit, without changing other orbital parameters. The maneuver includes three propulsive impulses to bring the spacecraft into and out of the atmosphere and to compensate for the velocity loss during the atmospheric passage. The total velocity change during this maneuver is compared to the velocity change of an optimal two-impulse pure propulsive maneuver and of a drag-only aeroassisted maneuver. It is shown that below a certain line of apside rotation angle the lift-controlled maneuver is more fuel economic than the drag-only maneuver. The lift-controlled maneuver is also more fuel economic than the pure propulsive maneuver, provided that the lift-to-drag ratio of the spacecraft is greater than 2. The limits to the rotation angle that can be achieved in a single pass are discussed. Numerical examples are presented. Author

A88-51716*# Mayflower Communications Co., Inc., Wakefield, MA.

FEASIBILITY OF USING GPS MEASUREMENTS FOR OMV ATTITUDE UPDATE

TRIVENI N. UPADHYAY, HARLEY RHODEHAMEL (Mayflower Communications Co., Inc., Wakefield, MA), and A. WAYNE DEATON (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Institute of Navigation, National Technical Meeting, Santa Barbara, CA, Jan. 26-29, 1988, Proceedings. Washington, DC, Institute of Navigation, 1988, p. 194-200. refs
(Contract NAS8-36363)

This paper presents the results of a feasibility study to determine whether the measurements from GPS satellites can be used to estimate the OMV attitude to an accuracy comparable to the onboard sun sensors, i.e., better than 0.5 degree in each axis. The results documented in this paper demonstrate that OMV attitude can be estimated to an accuracy of 0.1 - 0.5 degree in each axis by processing GPS measurements in an onboard integrated, 17-state GPS/inertial navigation filter. The result is particularly significant for missions of short duration burns where accurate attitude information is needed to minimize guidance and control errors. It is shown that the GPS attitude technique described in this paper can be easily implemented in the current OMV navigation system design. Results reported in this paper are expected to support the goal of developing a fault-tolerant guidance, navigation, and control system offering an improved total navigation performance for the OMV. Author

A88-52317

SPACE CONGRESS, 25TH, COCOA BEACH, FL, APR. 26-29, 1988, PROCEEDINGS

Congress sponsored by the Canaveral Council of Technical Societies. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, 592 p. For individual items see A88-52318 to A88-52373.

Papers are presented dealing with commercial aspects of space, space business, robotics, space station technologies, artificial intelligence applications in space, lunar and Mars exploration concepts, launch vehicles, and systems automation. Topics covered include ground processing of experiments conducted in space, the development of a commercial expendable launch vehicle industry, a small LEO satellite bus, epitaxial thin film growth in space, development of space enterprise, negotiating governmental contracts, robots in Shuttle hardware, telerobotic Space Station applications, simulation of an articulated transporter/manipulator system, welding the Space Station common module prototype, modeling the environment of the Man Tended Free Flyer, and Space Station rapid sample return. Ground operations support by AI, expert system prototype developments, Mars mission profile options and opportunities, launch vehicle operations analyses, space launch systems resiliency, model-based reasoning for knowledge-based software project management, technology advances for Space Shuttle processing, real-time fault management for large-scale systems, information systems for Shuttle processing, orbiter maneuvering vehicle support to the Space Station, and hydrogen-air-steam combustion regimes in large volumes are also discussed. R.B.

A88-52335

MODELLING OF THE MICROGRAVITY ENVIRONMENT OF THE MAN TENDED FREE FLYER (MTFF)

W. WOEHLKE (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-42 to 5-52. ESA-supported research. refs

One of the major purposes of the International Space Station (ISS) and MTFF is the performance of experiments and processes in a very low gravity environment. Considering the user's demands upon the microgravity quality, it appears more and more difficult to meet the corresponding requirements under worst case constraints. In this situation, the availability of an overall model as a tool for the assessment of the microgravity quality is of utmost importance. Based upon a critical review of the microgravity requirement in the time and frequency domain the present paper describes the development of an overall microgravity model to analyze both the low frequency microgravity distrubance sources such as air drag, gravity gradient and S/C dynamic and the high frequency microgravity disturbance sources such as reaction wheels, fluid loops, gyros, etc. The computerization of the comprehensive model exhibits the benefits of a computer aided design and engineering of future orbital systems, such as design optimization on system, subsystem, and assembly level with a quick access to various representations of microgravity performance such as vector fields, amplitude spectra, time profiles and envelopes. Author

A88-53242

EURECA TICCE - A NINE-MONTH SURVEY OF COSMIC DUST AND SPACE DEBRIS AT 500 KM ALTITUDE

T. J. STEVENSON (Kent, University, Canterbury, England) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 41, Sept. 1988, p. 429-432.

The Eureca-A timeband capture cell experiment is a modest extension of the time honored single foil capture cell technique for recovery of extraterrestrial material. The spacecraft, ostensibly designed for microgravity experimentation in low earth orbit, is the European retrievable carrier which takes advantage of the specific dimensions and payload launch capabilities of the United States Space Transportation System (the Space Shuttle), to provide a low cost reusable platform for missions, with durations of up to 9 months, not requiring celestial pointing. The experiment, of area 0.2 m, will probably return with about 1300 impact sites, each resolvable into a 2-3 day timeband during the flight. Author

A88-53749

SECOND THOUGHTS ON THE WAY TO THE STATION

DAVID BAKER New Scientist (ISSN 0028-6664), vol. 119, Aug. 25, 1988, p. 41-44.

The development of the Space Station is discussed. The stages of constructing the Station are presented, including an outline of the flights involved and what they would carry. The Station design is described and illustrated, including the elements of the Space Station contributed by Europe and Japan. Economic considerations, the problem of debris in space, and problems which might be caused by a delay during the stages of construction are considered. R.B.

A88-54766#

QUASAT - A 50,000 KM-DIAMETER QUASAR PROBE

U. FRISK, A. HAWKYARD, and J. W. CORNELISSE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 55, Aug. 1988, p. 18-23.

Quasat, an earth-orbiting radio antenna used in conjunction with ground-based VLBI networks to produce radio images at frequencies of 22, 5, 1.6, and 0.3 GHZ, is discussed. The Quasat mission would observe the compact, bright, high temperature objects in the nuclei of galaxies and quasars, in molecular masers, and on the surfaces of active stars in the Galaxy. The operational mission for Quasat is examined and the spacecraft configuration is described, including the radio-astronomy antenna, the spacecraft bus, and the booms which allow for viewing past the radio-astronomy antenna. The operational orbit of Quasat would have an apogee of about 37,000 km, with the space-borne antenna providing interferometer baselines ranging up to about 50,000 km. R.B.

A88-54876
DEVELOPMENTS IN MECHANICS. VOLUMES 14(A), 14(B), & 14(C) - MIDWESTERN MECHANICS CONFERENCE, 20TH, PURDUE UNIVERSITY, WEST LAFAYETTE, IN, AUG. 31-SEPT. 2, 1987, PROCEEDINGS
Conference sponsored by Purdue University. West Lafayette, IN, Purdue University, 1987, p. Vol. 14(a), 519 p.; vol. 14(b), 507 p.; vol. 14(c), 502 p. For individual items see A88-54877 to A88-54982.

Papers are presented on beam vibration, turbulent flow, pressure vessels, plasticity, fracture mechanics, stochastics, elastic stability, and space structures and bridges. Also considered are shell vibration, design optimization, plate vibration, numerical methods in fluid mechanics, contact mechanics, constitutive models, turbulent and wake flow, and buckling. Other topics include composite shells, nonlinear vibrations, suspended particles, geomechanics, acoustics, chaotic motion, and dissimilar materials. Papers are also presented on fluid-structure interactions, tribology, thermoelasticity, active vibration control, creep, vehicle and tire mechanics, and residual stresses. R.R.

A88-54994#
REDUCING THE COST AND RISK OF ORBIT TRANSFER
JAMES R. WERTZ, THOMAS L. MULLIKIN (Microcosm, Inc., Torrance, CA), and ROBERT F. BRODSKY (TRW, Inc., Redondo Beach, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, Jan.-Feb. 1988, p. 75-80. Previously cited in issue 08, p. 1059, Accession no. A87-22460. refs

A88-55331#
RISK MANAGEMENT FOR THE SPACE STATION PROGRAM
BAL KRISHAN (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p.
(IAF PAPER 88-061)

A risk management approach for the Space Station is presented, based on the principle that system acquisition is founded on the interrelation between design, testing, and production. A definition of risk is presented, and risk sources and control are discussed. The architecture of the risk management system is given. The three steps of the system's methodology are risk identification and assessment, risk prioritization, and risk resolution and statusing. A quantitative risk assessment model has been developed, identifying the most sensitive risk items. A production schedule and control system is being established to provide early warning and control of potential problems to ensure smooth transition from design to production and deployment. R.B.

A88-55336#
SPACE STATION HABITATION MODULE - PRIVACY AND COLLECTIVE LIFE
DANIELE BEDINI and ROBERTO PINOTTI (Futuro, Florence, Italy) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 11 p. refs
(IAF PAPER 88-080)

A design for the Space Station habitation module is proposed and illustrated. Problems in designing the module include creating an adaptable configuration, providing a design that will minimize psychological and sociological stress, allowing for an equilibrium between private and collective life. The need for architectural variety and flexibility of architectural elements is examined. The areas of the module are described, noting the possible uses of each section. R.B.

A88-55363#
DEVELOPMENT OF A GENERALIZED COST MODEL FOR LARGE SPACE POWER SYSTEMS
ALBIN D. KAZANOWSKI (Aerospace Corp., Los Angeles, CA) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 6 p. refs
(IAF PAPER 88-219)

A model for estimating weights and costs of large space electrical power systems is developed. It is valid for solar dynamic systems in the 50-150 kWe range and nuclear systems in the 50-500 kWe range. The model is expected to reduce the cost uncertainty of large space power systems from a factor of 5 to a range on the order of + or - 30 to 50 percent. K.K.

A88-55379*# Houston Univ., TX.
IDENTIFICATION OF LARGE STRUCTURES ON ORBIT - A SURVEY
EUGENE E. DENMAN (Houston, University, TX), JER-NAM JUANG (NASA, Langley Research Center, Hampton, VA), JOHN L. JUNKINS (Texas A & M University, College Station), MANOHAR KAMAT (Georgia Institute of Technology, Atlanta), T. K. HASSELMAN et al. IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 10 p. USAF-supported research. refs
(IAF PAPER 88-295)

This paper seeks to provide a brief overview of the somewhat unfamiliar concept underlying system identification especially as it applies to large flexible space structures. Having elaborated on the concept, the authors provide a detailed description of the identification process including model development, its experimental validation and final certification. This discussion is followed by a classification of the different identification methods and a brief evaluation of the potential of existing methodology to address special circumstances of large flexible space structures. The paper concludes by making a few recommendations that are deemed necessary to meet the enormous challenges posed by the deployment or erection of large space structures. Author

A88-55390#
FAST GEOSTATIONARY SATELLITE RELOCATION
GIACOMO PORCELLI (INTELSAT, Washington, DC) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 8 p. refs
(IAF PAPER 88-314)

A constrained, minimum-time transfer scheme for relocating a geostationary satellite to a nearby orbital location is described. The scheme is based on orbit tangential and radial thrusting (normally available on geostationary satellites) for the attainment of a direct transfer between the initial and final locations via a continuously powered trajectory. The trajectory determination algorithm is presented first. The algorithm generates the trajectory control requirements, the total relocation time, and the required velocity increments. Curves of relocation time and velocity increment versus the orbital relocation angle, for various acceleration levels, are derived. A comparative discussion of the trade-offs of this approach versus the commonly used impulsive transfer is included. Author

A88-55486
SPACE STATION - HOME AND WORKPLACE IN ORBIT
JERRY GOLDMACHER and JOHN MOCKOVCIAK, JR. (Grumman Corp., Bethpage, NY) Horizons (ISSN 0095-7615), vol. 24, no. 1, 1988, p. 10-15, 17.

The design of the Space Station is examined, focusing on plans for the living quarters. The process for building the station in space is outlined and the construction of a mockup of the habitation module are considered. Problems in designing the living quarters include accounting for the size range of astronauts, providing privacy, noise reduction, creating an area suitable for exercise, and allowing enough storage space. Plans for maintaining a sterile laboratory and providing equipment for personal hygiene are presented. The ability to repair all of the Space Station equipment in place and plans for dealing with emergency situations are discussed. R.B.

N88-20329# Joint Publications Research Service, Arlington, VA.
FEATURES OF SOYUZ TM SPACECRAFT
YU. SEMENOV and V. TIMCHENKO *In its* JPRS Report: Science and Technology. USSR: Space p 35-41 6 Apr. 1988 Transl. into ENGLISH from Pravda (Moscow, USSR), 5 Aug. 1987 p 3
Avail: NTIS HC A04/MF A01

The Soyuz TM spacecraft is discussed. The descent module, propulsion system, inertial guidance system, and docking equipment and procedures are described. R.J.F.

N88-21193# Teldix Luftfahrt-Ausruestungs G.m.b.H., Heidelberg (Germany, F.R.).
HEMISPHERICAL POINTING MECHANISM DRIVE UNIT
H. H. SCHULTZ *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 11-14 Dec. 1987
Avail: NTIS HC A14/MF A01

A wide angle pointing device for controlling medium sized instrument and antenna payloads in the 10 to 50 kg range for missions requiring angular coverage of at least a hemisphere with a pointing accuracy of the order of 1 arcmin was developed. The drive unit which is the main part of the Hemispherical Pointing Mechanism (HPM) is a lightweight, pancake shaped package. It contains the motor, the reduction gear, the bearing, and the angular encoder. Results of a life test and breadboard model tests are presented. The HPM drive unit demonstrates that it can be used not only in the HPM but also for applications such as antenna pointing, bearing and power transfer, momentum wheel gimballing, control moment gyros, and robotics. ESA

N88-21242*# California Univ., Davis. Dept. of Psychology.
INCORPORATION OF PRIVACY ELEMENTS IN SPACE STATION DESIGN Final Report, 1 Jan. - 31 Dec. 1987
ALBERT A. HARRISON, BARRETT CALDWELL, and NANCY J. STRUTHERS 20 May 1988 60 p
(Contract NAG2-431)
(NASA-CR-182748; NAS 1.26:182748) Avail: NTIS HC A04/MF A01 CSCL 22B

Privacy exists to the extent that individuals can control the degree of social contact that they have with one another. The opportunity to withdraw from other people serves a number of important psychological and social functions, and is in the interests of safety, high performance, and high quality of human life. Privacy requirements for Space Station crew members are reviewed, and architectual and other guidelines for helping astronauts achieve desired levels of privacy are suggested. In turn, four dimensions of privacy are discussed: the separation of activities by areas within the Space Station, controlling the extent to which astronauts have visual contact with one another, controlling the extent to which astronauts have auditory contact with one another, and odor control. Each section presents a statement of the problem, a review of general solutions, and specific recommendations. The report is concluded with a brief consideration of how selection, training, and other procedures can also help Space Station occupants achieve satisfactory levels of seclusion. Author

N88-21468*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE 22ND AEROSPACE MECHANISMS SYMPOSIUM
May 1988 416 p Symposium held in Hampton, Va.; sponsored by NASA, Washington, California Inst. of Tech., Pasadena, and LMSC, Sunnyvale, Calif.
(NASA-CP-2506; L-16433; NAS 1.55:2506) Avail: NTIS HC A18/MF A01 CSCL 20K

The proceedings of the symposium, which was held at the NASA Langley Research Center, on May 4 to 6, 1988, are reported. Technological areas covered include space lubrication, bearings, aerodynamic devices, spacecraft latches, deployment, positioning, and pointing. Devices for space station docking and manipulator and teleoperator mechanisms are also described.

N88-21488*# Astro Aerospace Corp., Carpinteria, CA.
SPACE STATION MOBILE TRANSPORTER
JAMES RENSHALL, GEOFF W. MARKS, and GRANT L. YOUNG *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium p 271-286 May 1988
Avail: NTIS HC A18/MF A01 CSCL 22B

The first quarter of the next century will see an operational space station that will provide a permanently manned base for satellite servicing, multiple strategic scientific and commercial payload deployment, and Orbital Maneuvering Vehicle/Orbital Transfer Vehicle (OMV/OTV) retrieval replenishment and deployment. The space station, as conceived, is constructed in orbit and will be maintained in orbit. The construction, servicing, maintenance and deployment tasks, when coupled with the size of the station, dictate that some form of transportation and manipulation device be conceived. The Transporter described will work in conjunction with the Orbiter and an Assembly Work Platform (AWP) to construct the Work Station. The Transporter will also work in conjunction with the Mobile Remote Servicer to service and install payloads, retrieve, service and deploy satellites, and service and maintain the station itself. The Transporter involved in station construction when mounted on the AWP and later supporting a maintenance or inspection task with the Mobile Remote Servicer and the Flight Telerobotic Servicer is shown. Author

N88-22224# Joint Publications Research Service, Arlington, VA.
JAPANESE SPACE STATION MODULE
AKIRA B. SAWAOKA *In its* JPRS Report: Science and Technology Japan p 30-31 3 Mar. 1988 Transl. into ENGLISH from Ceramics Japan (Tokyo, Japan), Apr. 1987 p 297-302
Avail: NTIS HC A05/MF A01

Japan is scheduled to build a space station in the 1990s. It will not be a whole space station, but a space station module to be docked with the NASA space station. The module to be build by Japan is comprised of a space laboratory called JEM (Japanese Experiment Module). The total cost of JEM, including the cost of experimental apparatus to be installed and the expenses for operation in the initial stage, will amount to well over ¥300 billion. The JEM will measure about 4 m in diameter and 18 m in length. A total of four modules, including JEM, are scheduled to be docked with the space station proper. The design of the JEM and the goals of the Japanese Space Program are discussed. Author

N88-23226*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LEWIS STRUCTURES TECHNOLOGY, 1988. VOLUME 1: STRUCTURAL DYNAMICS
May 1988 463 p Symposium held in Cleveland, Ohio, 24-25 May 1988
(NASA-CP-3003-VOL-1; E-3970-VOL-1; NAS 1.55:3003-VOL-1)
Avail: NTIS HC A20/MF A01 CSCL 20K

The specific purpose of the symposium was to familiarize the engineering structures community with the depth and range of research performed by the Structures Division of the Lewis Research Center and its academic and industrial partners. Sessions covered vibration control, fracture mechanics, ceramic component reliability, parallel computing, nondestructive testing, dynamical systems, fatigue and damage, wind turbines, hot section technology, structural mechanics codes, computational methods for dynamics, structural optimization, and applications of structural dynamics.

N88-23813# Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.).
ARGUMENTS FOR MANNED OR UNMANNED SPACECRAFT ACTIVITIES [ARGUMENTE FUER BEMANNTE UND UNBEMANNTE WELTRAUMAKTIVITAETEN]
19 Oct. 1987 20 p In GERMAN
(REPT-46/87; ETN-88-91949) Avail: NTIS HC A03/MF A01

Arguments for the critical assessment of technology needs to prepare manned spacecraft activities are presented. Studies in materials structure sciences and biosciences are especially required as for the FSLP and D1 missions. This evaluation suggests the possible substitution of man by automation in space experiments. Developments in this field are reviewed. ESA

N88-23823# Science Applications International Corp., McLean, VA.
SOVIET SPACECRAFT ENGINEERING RESEARCH
J. F. GARIBOTTI, M. ASWANI, E. F. CRAWLEY, W. C. KESSLER,

K. SOOSAAR, J. D. TURNER, and W. P. WITT Oct. 1987
164 p
(FASAC-TAR-3090) Avail: NTIS HC A08/MF A01

The Soviet published literature in spacecraft engineering pertaining to future space systems, including those utilizing large structures is assessed. Topical areas emphasized include advanced structural concepts and associated construction approaches, spacecraft materials, precision pointing and rapid retargeting, geometrically precise structures in the presence of static and dynamic disturbances, and spacecraft vulnerability as it relates to these aspects of spacecraft engineering. The assessment indicates that the Soviets have significant strengths and specialties in spacecraft engineering. The Soviet space station appears to be the principal Soviet large system of the near future, and this will expand and evolve in size and capability. Radio astronomy missions are also genuine drivers for large space structure technology, including space construction capability. In the structural materials area, the Soviets can be expected to develop high quality, structurally efficient fiber-reinforced metal-matrix composites, which will be used to improve the performance and possibly the survivability of future Soviet spacecraft. The technology of control-structure interaction, important in the design of large space-based lasers, is receiving considerably more support, based on the published literature, in the United States than in the Soviet Union.
Author

N88-23929*# Houston Univ., TX. Applied Electromagnetics Lab.
AN INVESTIGATION OF CONFORMABLE ANTENNAS FOR THE ASTRONAUT BACKPACK COMMUNICATION SYSTEM Final Report
STUART A. LONG, DAVID R. JACKSON, JEFFERY T. WILLIAMS, and DONALD R. WILTON 1 Jun. 1988 190 p
(Contract NAG9-219)
(NASA-CR-182908; NAS 1.26:182908; TR-88-18) Avail: NTIS HC A09/MF A01 CSCL 17B

During periods of extravehicular activity it is obviously important that communication and telemetry systems continue to function independently of the astronaut. A system of antennas must therefore be designed that will provide the necessary isotropic coverage using circular polarization over both the transmit and receive frequency bands. To avoid the inherent physical limitations to motion that would be incurred with any sort of protruding antenna, it is necessary that the radiator be essentially flush-mounted or conformable to the structure on which it is attached. Several individual antenna elements are needed for the desired coverage. Both the particular elements chosen and their location determine the ultimate radiation pattern of the overall system. For these reasons a two-fold research plan was undertaken. First, individual elements were investigated and designed. Then various mounting locations were considered and the radiation patterns were predicted taking into account the effects of the astronaut's backpack.
Author

N88-24145*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPACE STATION HUMAN FACTORS RESEARCH REVIEW. VOLUME 1: EVA RESEARCH AND DEVELOPMENT
MARC M. COHEN, ed. and H. C. VYKUKAL, ed. Apr. 1988 136 p Workshop held at Moffett Field, Calif., 3-6 Dec. 1985
(NASA-CP-2426-VOL-1; A-87163-VOL-1; NAS 1.55:2426-VOL-1)
Avail: NTIS HC A07/MF A01 CSCL 06B

An overview is presented of extravehicular activity (EVA) research and development activities at Ames. The majority of the program was devoted to presentations by the three contractors working in parallel on the EVA System Phase A Study, focusing on Implications for Man-Systems Design. Overhead visuals are included for a mission results summary, space station EVA requirements and interface accommodations summary, human productivity study cross-task coordination, and advanced EVAS Phase A study implications for man-systems design. Articles are also included on subsea approach to work systems development and advanced EVA system design requirements.

N88-24146*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SUBSEA APPROACH TO WORK SYSTEMS DEVELOPMENT
M. L. GERNHARDT, F. R. FRISBIE, and C. E. BROWN *In its* Space Station Human Factors Research Review. Volume 1: EVA Research and Development p 69-84 Apr 1988 Sponsored by Oceaneering International
Avail: NTIS HC A07/MF A01 CSCL 05H

Self-contained undersea working environments with applications to space station EVA environments are discussed. Physiological limitations include decompression, inert gas narcosis, high-pressure nervous system, gas toxicity, and thermal limitations. Work task requirements include drilling support, construction, inspection, and repair. Work systems include hyperbaric diving, atmospheric work systems, tele-operated work systems, and hybrid systems. Each type of work system is outlined in terms of work capabilities, special interface requirements, and limitations. Various operational philosophies are discussed. The evolution of work systems in the subsea industry has been the result of direct operational experience in a competitive market.
J.P.B.

N88-24148*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPACE STATION HUMAN FACTORS RESEARCH REVIEW. VOLUME 4: INHOUSE ADVANCED DEVELOPMENT AND RESEARCH
TRIEVE TANNER, ed., YVONNE A. CLEARWATER, ed., and MARC M. COHEN, ed. May 1988 135 p Workshop held at Moffett Field, Calif., 3-6 Dec. 1985
(NASA-CP-2426-VOL-4; A-87247-VOL-4; NAS 1.55:2426-VOL-4)
Avail: NTIS HC A07/MF A01 CSCL 06B

A variety of human factors studies related to space station design are presented. Subjects include proximity operations and window design, spatial perceptual issues regarding displays, image management, workload research, spatial cognition, virtual interface, fault diagnosis in orbital refueling, and error tolerance and procedure aids.

N88-24150*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
IMAGE MANAGEMENT RESEARCH
ANDREW B. WATSON *In its* Space Station Human Factors Research Review. Volume 4: Inhouse Advanced Development and Research p 23-28 May 1988
Avail: NTIS HC A07/MF A01 CSCL 05H

Two types of research issues are involved in image management systems with space station applications: image processing research and image perception research. The image processing issues are the traditional ones of digitizing, coding, compressing, storing, analyzing, and displaying, but with a new emphasis on the constraints imposed by the human perceiver. Two image coding algorithms have been developed that may increase the efficiency of image management systems (IMS). Image perception research involves a study of the theoretical and practical aspects of visual perception of electronically displayed images. Issues include how rapidly a user can search through a library of images, how to make this search more efficient, and how to present images in terms of resolution and split screens. Other issues include optimal interface to an IMS and how to code images in a way that is optimal for the human perceiver. A test-bed within which such issues can be addressed has been designed.
J.P.B.

N88-24151*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NASA-AMES WORKLOAD RESEARCH PROGRAM
SANDRA HART *In its* Space Station Human Factors Research Review. Volume 4: Inhouse Advanced Development and Research p 29-76 May 1988
Avail: NTIS HC A07/MF A01 CSCL 05H

Research has been underway for several years to develop valid and reliable measures and predictors of workload as a function of operator state, task requirements, and system resources. Although the initial focus of this research was on aeronautics, the underlying principles and methodologies are equally applicable to space, and provide a set of tools that NASA and its contractors can use to evaluate design alternatives from the perspective of the astronauts. Objectives and approach of the research program are described, as well as the resources used in conducting research and the conceptual framework around which the program evolved. Next, standardized tasks are described, in addition to predictive models and assessment techniques and their application to the space program. Finally, some of the operational applications of these tasks and measures are reviewed. Author

N88-24152*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPATIAL COGNITION
MARY KISTER KAISER and ROGER REMINGTON *In its* Space Station Human Factors Research Review. Volume 4: Inhouse Advanced Development and Research p 77-83 May 1988
Avail: NTIS HC A07/MF A01 CSCL 05I

Spatial cognition is the ability to reason about geometric relationships in the real (or a metaphorical) world based on one or more internal representations of those relationships. The study of spatial cognition is concerned with the representation of spatial knowledge, and our ability to manipulate these representations to solve spatial problems. Spatial cognition is utilized most critically when direct perceptual cues are absent or impoverished. Examples are provided of how human spatial cognitive abilities impact on three areas of space station operator performance: orientation, path planning, and data base management. A videotape provides demonstrations of relevant phenomena (e.g., the importance of orientation for recognition of complex, configural forms). The presentation is represented by abstract and overhead visuals only. Author

N88-24188*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
THIRD CONFERENCE ON ARTIFICIAL INTELLIGENCE FOR SPACE APPLICATIONS, PART 2
JUDITH S. DENTON, comp., MICHAEL S. FREEMAN, comp., and MARY VEREEN, comp. Jun. 1988 66 p Conference held in Huntsville, Ala., 2-3 Nov. 1987; sponsored by NASA, Marshall Space Flight Center, Huntsville, Ala. and Alabama Univ., Huntsville Sponsored by NASA, Washington
(NASA-CP-2492-PT-2; M-576-PT-2; NAS 1.55:2492-PT-2) Avail: NTIS HC A04/MF A01 CSCL 09B

Topics relative to the application of artificial intelligence to space operations are discussed. New technologies for space station automation, design data capture, computer vision, neural nets, automatic programming, and real time applications are discussed.

N88-24632*# Taylor and Associates, Inc., Wrightwood, CA.
SPACE STATION ARCHITECTURAL ELEMENTS MODEL STUDY
T. C. TAYLOR, J. S. SPENCER, C. J. ROCHA, E. KAHN, E. CLIFFTON, and C. CARR Washington NASA Jan. 1987 155 p
(NASA-CR-4027; NAS 1.26:4027) Avail: NTIS HC A08/MF A01 CSCL 01C

The worksphere, a user controlled computer workstation enclosure, was expanded in scope to an engineering workstation suitable for use on the Space Station as a crewmember desk in orbit. The concept was also explored as a module control station capable of enclosing enough equipment to control the station from each module. The concept has commercial potential for the Space Station and surface workstation applications. The central triangular beam interior configuration was expanded and refined to seven different beam configurations. These included triangular on center, triangular off center, square, hexagonal small, hexagonal medium, hexagonal large and the H beam. Each was explored with some considerations as to the utilities and a suggested evaluation factor methodology was presented. Scale models of each concept were made. The models were helpful in researching the seven beam configurations and determining the negative residual (unused) volume of each configuration. A flexible hardware evaluation factor concept is proposed which could be helpful in evaluating interior space volumes from a human factors point of view. A magnetic version with all the graphics is available from the author or the technical monitor. Author

N88-25156*# McDonnell-Douglas Astronautics Co., Huntington Beach, CA.
HUMAN PERFORMANCE ISSUES ARISING FROM MANNED SPACE STATION MISSIONS
WILLIAM K. DOUGLAS Washington NASA Oct. 1986 61 p
(Contract NAS2-11723)
(NASA-CR-3942; NAS 1.26:3942; MDC-H1363) Avail: NTIS HC A04/MF A01 CSCL 05H

Ten former NASA astronauts were interviewed using a set of 51 questions developed to encourage the contacts to discuss any thoughts, opinions, conclusions, or suggestions which might have evolved since they left the astronaut program. Strict confidentiality was maintained. At least one astronaut from each of the NASA manned space flight programs, excluding the Space Transportation System (Shuttle), was interviewed. The report records the answers to the questions asked, spontaneous comments, and the investigator's own personal evaluations of the material obtained. No statistical analysis of the material was attempted. The professional opinions of these ten experienced astronauts will be of value to persons concerned with the design and operation of manned spacecraft and manned space stations. Author

N88-26023# Centre d'Essais en Vol, Bretigny-Air (France). Lab. de Medecine Aerospatiale.
SPACE CABIN ATMOSPHERE AND EXTRACURRICULAR SORTIE [ATMOSPHERE D'UNE CABINE SPATIALE ET SORTIE EXTRA-VEHICULAIRE]
HENRI MAROTTE and MARC WEIBEL (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France) *In* ESA, Proceedings of the Colloquium on Space and Sea p 69-76 Mar. 1988 In FRENCH
Avail: NTIS HC A15/MF A01

Conditions which provoke aeroembolism were studied to help design space suits which reduce risks entailed in passing from the terrestrial like conditions of a spacecraft cabin atmosphere to the medium and low pressures of space suits. Design constraints on the suite and its pressurizing system were evaluated, especially for the working conditions of space stations, which require frequent extravehicular activity. Given the limits imposed by denitrogenation, a high pressure (at least 650 hPa) is suggested for the American space station program, whereas for ESA, use of Hermes is compatible with a 450 hPa suit. For intravehicular emergency suits, pressure should be as high as compatible with mobility requirements (bearing in mind the reduced level of physical activity). ESA

N88-27214* National Aeronautics and Space Administration, Washington, DC.
TECHNOLOGY FOR LARGE SPACE SYSTEMS: A BIBLIOGRAPHY WITH INDEXES (SUPPLEMENT 18)
Jun. 1988 162 p
(NASA-SP-7046(18); NAS 1.21:7046(18)) Avail: NTIS HC A07 CSCL 22B

This bibliography lists 569 reports, articles, and other documents introduced into the NASA scientific and technical information system between July 1,1987 and December 31, 1987. Its purpose is to provide helpful information to the researcher, manager, and designer in technology development and mission design according to system, interactive analysis and design, structural and thermal analysis and design, structural concepts and control systems, electronics, advanced materials, assembly concepts, propulsion, and solar power satellite systems. Author

N88-27760*# TRW Defense and Space Systems Group, Redondo Beach, CA.
BLOCK ORIENTED SIMULATION SYSTEM (BOSS)
JAIMIE RATCLIFFE 1988 45 p Submitted for publication

(Contract NAS9-17677)
(NASA-CR-182947; NAS 1.26:182947) Avail: NTIS HC A03/MF A01 CSCL 09B

Computer simulation is assuming greater importance as a flexible and expedient approach to modeling system and subsystem behavior. Simulation has played a key role in the growth of complex, multiple access space communications such as those used by the space shuttle and the TRW-built Tracking and Data Relay Satellites (TDRS). A powerful new simulator for use in designing and modeling the communication system of NASA's planned Space Station is being developed. Progress to date on the Block (Diagram) Oriented Simulation System (BOSS) is described. B.G.

N88-29379*# Alabama Univ., Huntsville.
OMV DOCKING SIMULATOR
W. TEOH and J. HAWKINS (Boeing Aerospace Co., Huntsville, Ala.) *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 257-276 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 14B

The Boeing Orbital Maneuvering Vehicle (OMV) Docking and Proximity Operation System (DAPOS) was completed. The system constructed involves the use of four separate processors. Appropriate software was developed that drives each of these four processors. The hand controller logic coordinates all the activities in the control station, and communicates with the OMV mathematical model. The state vector generated by the model is in turn transmitted to the control station as well as the POLY 2000 (via the ALCYON host computer) for real time graphics generation. The OMV characteristics are stored in a data file which may be easily updated and modified without disturbing the software, thereby making the system very flexible. The current system supports two types of hand controllers. The system was flown by several volunteers, some of whom are airplane pilots. A user manual is also enclosed. Author

N88-29380*# Martin Marietta Aerospace, Denver, CO. Space Station Program.
ARGES: AN EXPERT SYSTEM FOR FAULT DIAGNOSIS WITHIN SPACE-BASED ECLS SYSTEMS
DAVID W. PACHURA, SALEM A. SULEIMAN, and ANDREW P. MENDLER *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 277-282 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

ARGES (Atmospheric Revitalization Group Expert System) is a demonstration prototype expert system for fault management for the Solid Amine, Water Desorbed (SAWD) CO2 removal assembly, associated with the Environmental Control and Life Support (ECLS) System. ARGES monitors and reduces data in real time from either the SAWD controller or a simulation of the SAWD assembly. It can detect gradual degradations or predict failures. This allows graceful shutdown and scheduled maintenance, which reduces crew maintenance overhead. Status and fault information is presented in a user interface that simulates what would be seen by a crewperson. The user interface employs animated color graphics and an object oriented approach to provide detailed status information, fault identification, and explanation of reasoning in a rapidly assimulated manner. In addition, ARGES recommends possible courses of action for predicted and actual faults. ARGES is seen as a forerunner of AI-based fault management systems for manned space systems. Author

N88-29383*# Martin Marietta Aerospace, Denver, CO.
A SCHEDULING AND RESOURCE MANAGEMENT SYSTEM FOR SPACE APPLICATIONS
DANIEL L. BRITT, AMY L. GEOFFROY, and JOHN R. GOHRING *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 303-310 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05A

Every spacecraft, whether in orbit around the earth or on a deep space flight, has at its disposal limited amounts of the resources for it to accomplish its mission. Activity scheduling is currently a costly, human intensive task which requires a great deal of expertise. It belongs to a class of problems whose complexity increases exponentially with the number of operations. NASA has in the past accomplished this task by using a great deal of manpower, a large number of negotiating sessions, interminable bouts of phone tag, and mountains of paperwork. Lately the situation has improved with the introduction of automated scheduling techniques, but these to date still require expert involvement and fall short in some important ways. A prototype activity scheduler, MAESTRO, is introduced which is capable of meeting the needs of many NASA missions, eventually to include the Space Station. The approach to resource constrained scheduling is first discussed, then the intended domain for MAESTRO is described along with its design and current capabilities. A description of planned enhancements and revisions to the systems is also presented. Author

N88-29417*# Boeing Aerospace Co., Huntsville, AL. Space Station Program.
A NONLINEAR FILTERING PROCESS DIAGNOSTIC SYSTEM FOR THE SPACE STATION
RAYMOND R. YOEL, M. BUCHNER, K. LOPARO, and ARIF CUBUKCU (Case Western Reserve Univ., Cleveland, Ohio.) *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 601-604 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

A nonlinear filtering process diagnostic system, terrestrial simulation and real time implementation studies is presented. Possible applications to Space Station subsystem elements are discussed. A process diagnostic system using model based nonlinear filtering for systems with random structure was shown to provide improvements in stability, robustness, and overall performance in comparison to linear filter based systems. A suboptimal version of the nonlinear filter (zero order approximation filter, or ZOA filter) was used in simulation studies, initially, with a pressurized water reactor model and then with water/steam heat exchanger models. Finally, a real time implementation for leak detection in a water/steam heat exchanger was conducted using the ZOA filter and heat exchanger models. Author

N88-29835*# General Dynamics Corp., San Diego, CA.
CENTAUR OPERATIONS AT THE SPACE STATION: COST AND TRANSPORTATION ANALYSIS Final Report
10 Aug. 1988 241 p
(Contract NAS3-24900)
(NASA-CR-182128; NAS 1.26:182128; GDSS-SP-88-006) Avail: NTIS HC A11/MF A01 CSCL 22B

A study was conducted to expand on the results of an initial study entitled Centaur Operations at the Space Station. The previous study developed technology demonstration missions (TDMs) that utilized the Centaur G-prime upper stage to advance OTV technologies required for accomodations and operations at the Space Station. An initial evaluation was performed of the cost to NASA for TDM implementation. Due to the potential for commercial communication satellite operation utilizing the TDM hardware, an evaluation of the Centaur's transportation potential was also performed. Author

N88-30301*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPACE STATION PROXIMITY OPERATIONS WINDOWS: HUMAN FACTORS DESIGN GUIDELINES
RICHARD F. HAINES Mar. 1987 109 p
(NASA-TM-88233; A-86185; NAS 1.15:88233) Avail: NTIS HC A06/MF A01 CSCL 06K

Proximity operations refers to all activities outside the Space Station which take place within a 1-km radius. Since there will be a large number of different operations involving manned and unmanned vehicles, single- and multiperson crews, automated and manually controlled flight, a wide variety of cargo, and construction/repair activities, accurate and continuous human

monitoring of these operations from a specially designed control station on Space Station will be required. Total situational awareness will be required. This paper presents numerous human factors design guidelines and related background information for control windows which will support proximity operations. Separate sections deal with natural and artificial illumination geometry; all basic rendezvous vector approaches; window field-of-view requirements; window size; shape and placement criteria; window optical characteristics as they relate to human perception; maintenance and protection issues; and a comprehensive review of windows installed on U.S. and U.S.S.R. manned vehicles.
Author

N88-30330*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

THE 1988 GODDARD CONFERENCE ON SPACE APPLICATIONS OF ARTIFICIAL INTELLIGENCE

JAMES RASH, ed. and PETER HUGHES, ed. Aug. 1988 437 p Conference held in Greenbelt, Md., 24 May 1988 Sponsored by NASA, Washington, D.C.

(NASA-CP-3009; REPT-88B0212; NAS 1.55:3009) Avail: NTIS HC A19/MF A01 CSCL 09B

This publication comprises the papers presented at the 1988 Goddard Conference on Space Applications of Artificial Intelligence held at the NASA/Goddard Space Flight Center, Greenbelt, Maryland on May 24, 1988. The purpose of this annual conference is to provide a forum in which current research and development directed at space applications of artificial intelligence can be presented and discussed. The papers in these proceedings fall into the following areas: mission operations support, planning and scheduling; fault isolation/diagnosis; image processing and machine vision; data management; modeling and simulation; and development tools/methodologies.

N88-30333*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A SHARED-WORLD CONCEPTUAL MODEL FOR INTEGRATING SPACE STATION LIFE SCIENCES TELESCIENCE OPERATIONS

VICKI JOHNSON and JOHN BOSLEY (Bionetics Corp., Moffett Field, Calif.) *In* NASA, Goddard Space Flight Center, The 1988 Goddard Conference on Space Applications of Artificial Intelligence p 33-44 Aug. 1988

Avail: NTIS HC A19/MF A01 CSCL 09B

Mental models of the Space Station and its ancillary facilities will be employed by users of the Space Station as they draw upon past experiences, perform tasks, and collectively plan for future activities. The operational environment of the Space Station will incorporate telescience, a new set of operational modes. To investigate properties of the operational environment, distributed users, and the mental models they employ to manipulate resources while conducting telescience, an integrating shared-world conceptual model of Space Station telescience is proposed. The model comprises distributed users and resources (active elements); agents who mediate interactions among these elements on the basis of intelligent processing of shared information; and telescience protocols which structure the interactions of agents as they engage in cooperative, responsive interactions on behalf f users and resources distributed in space and time. Examples m the life sciences are used to instantiate and refine the model's nciples. Implications for transaction management and autonomy are discussed. Experiments employing the model are described which the authors intend to conduct using the Space Station Life Sciences Telescience Testbed currently under development at Ames Research Center.
Author

N88-30556# European Space Agency, Paris (France). Space Science Dept.

ESA REPORT TO THE 27TH COSPAR MEETING

V. DOMINGO, U. O. FISK, R. GRARD, P. JAKOBSEN, M. F. KESSLER, J.-P. LEBRETON, R. MARSDEN, A. PEACOCK, A. PEDERSON, M. A. C. PERRYMAN et al. Jun. 1988 148 p Meeting held in Helsinki, Finland, Jul. 1988 Original contains color illustrations

(ESA-SP-1098; ISSN-0379-6566; ETN-88-93046) Avail: NTIS HC A07/MF A01

The ISEE, IUE, EXOSAT, and Giotto missions are described. The status of the Ulysses, Hubble Space Telescope, HIPPARCOS, ISO, and solar-terrestrial science programs is discussed. The high throughput X-ray spectroscopy mission, submillimeter spectroscopy mission, and the comet nucleus sample return mission are presented. The CASSINI, GRASP, Lyman, Quasat, Vesta, and Giotto extended missions are introduced. The EURECA and Columbus space station programs are reviewed.
ESA

N88-30582# Politecnico di Torino (Italy). Dept. of Aerospace Engineering.

ACTIVITIES REPORT OF THE DEPARTMENT OF AEROSPACE ENGINEERING Annual Report, 1986

Dec. 1987 37 p

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Research in aeronautics and astronautics; fluid dynamics and propulsion; structures and materials; and systems engineering and management is summarized.
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TECHNOLOGY FOR LARGE SPACE SYSTEMS / *A Bibliography (Supplement 20)* JUNE 1989

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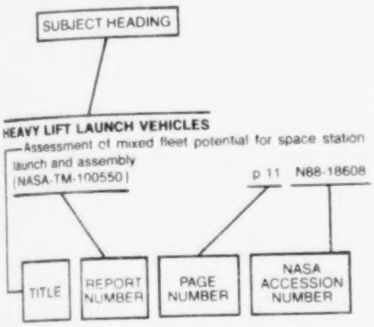
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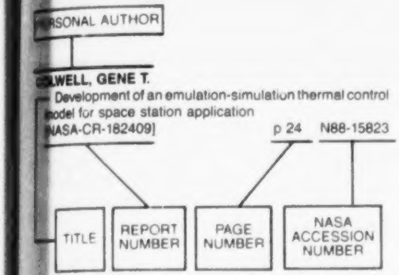

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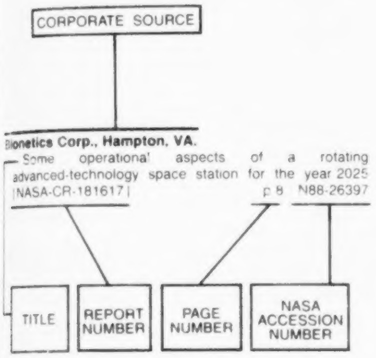
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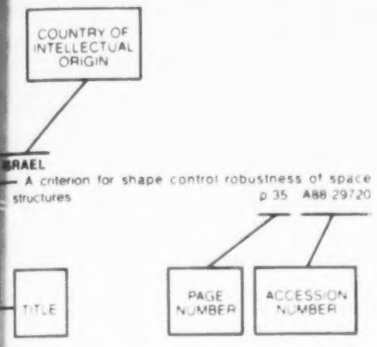
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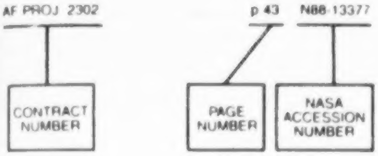

Listings in this index are arranged alphanumerically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under that contract are arranged in ascending order with the AIAA accession numbers appearing first. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

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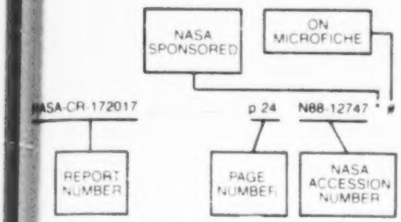

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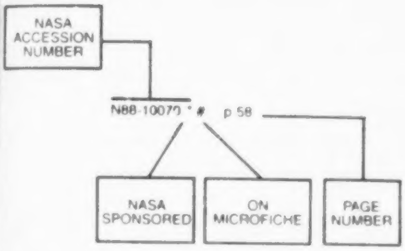

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